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AREAL EXTENT AND THICKNESS OF THE SALT DEPOSITS OF OHIO[1]

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INTRODUCTION

Beds of rock salt occur in Ohio in rocks of the Salina formation of the upper Silurian. Since 1889 salt has been manufactured commercially from these beds by pumping fresh water into wells drilled to the salt beds and repumping the brine to the surface, where it is processed. Salt, which is one of the basic raw materials of the chemical industry, is a commercial resource of great and increasing value to Ohio.[2] [3] [4]

In order to furnish information that may be useful to operators desiring suitable locations for salt plants, a regional study has been made to determine the western limits of the occurrence of beds of salt in Ohio, the total thickness of salt beds within the area of occurrence, and the depth to the top of the highest salt bed in the section at any place. The study is based on an examination of the records of salt beds contained in well logs in the files of the U. S. Geological Survey and on the results of examinations of samples by R. E. Lamborn of the Geological Survey of Ohio. No attempt is made in this report to discuss the general stratigraphic correlations of the Silurian salt sequence of Ohio to the salt-bearing Salina formation of Cayuga (Silurian) age of other areas, or to suggest the possible origin and manner of deposition of the salt.

ACKNOWLEDGMENTS

The drillers' records of wells used in compiling the salt data were obtained from the Ohio Division of Mines and the Geological Department of The Ohio Fuel Gas Company. The cooperation of these organizations is gratefully acknowledged. The writer gratefully acknowledges the assistance and kind criticism of Dr. George White and Mr. R. E. Lamborn of the Geological Survey of Ohio. Mr. Lamborn supplied the records of sample wells which he had examined, together with much assistance in the calculation of the estimated original thicknesses of the several salt beds. Messrs. H. D. Miser, C. H. Dane, and R. E. Van Alstine of the U. S. Geological Survey kindly read and criticized the manuscript. The writer wishes to thank Mrs. Violet M. Massarelli for her assistance in compiling the data on which the report was based and for drafting the accompanying maps.

[1]Published by permission of the Director, U. S. Geological Survey, and the State Geologist of Ohio.

[2]Hildreth, S. P. Salt Springs: Early History of Salt Manufacture in Ohio, [reprint] in Ohio's Mineral Resources, III. Salt: Ohio State Univ. Eng. Exper. Sta. Circ. no. 47, vol. XIV, no. 2, pp. 1–12, July, 1945.

[3]Harris, W. R., and Corell, E. J. Industrial Development of Salt Manufacture in Ohio, in Ohio's Mineral Resources, III. Salt: Ohio State Univ. Eng. Exper. Sta. Circ. no. 47, vol. XIV, no. 2, pp. 13–19, July, 1945.

[4]Gambs, G. C., and White, G. W. Ohio's Mineral Resources, III. Salt reserves (Third in a series on salt): Ohio State Univ. Eng. Exper. Sta. Circ. no. 49, vol. XV, no. 3, pp. 1–22, September, 1946.

DATA UPON WHICH THE STUDY WAS BASED

The data on which this study was based were derived chiefly from an examination of the records of 3,555 wells drilled for oil or gas to the horizon of the Clinton sand, which lies below the salt series in east-central Ohio. In eastern Ohio along the Ohio-Pennsylvania border few wells have been drilled through the salt series, and drilling information is thus available at only widely scattered points. The following table shows the number of well records examined:

NUMBER OF WELL RECORDS, TO THE CLINTON SAND, USED IN COMPILING SALT DATA

County	From U. S. Geological Survey Files		From Sample Records by R. E. Lamborn†
	Total Number	Number which Record Salt	
Ashtabula	37	16	3
Belmont	1	1	1
Carroll	4	4	1
Columbiana	5	4	.....
Cuyahoga	20	13	.....
Geauga	12	8	.....
Harrison	12	10	2
*Holmes	702	12	.....
Lake	19	14	1
Mahoning	6	2	1
Medina	210	54	.....
Portage	16	12	.....
Stark	794	755	2
Summit	245	182	.....
Trumbull	13	11	1
*Tuscarawas	244	184	3
Washington	1	1	.....
*Wayne	1,214	113	.....
Totals	3,555	1,396	15

*Salt is not present west of a line which passes through the county.
†See logs at end of report.

The table shows that no salt is recorded in many drillers' records of wells within the area of salt deposition in Ohio. Salt may not have been present in some of the wells, but it is doubtful that salt beds are absent over extensive areas. Probably most of the wells passed through beds of salt, but the driller failed to observe these beds because they are thin, or, if thick, are interbedded with dolomite, anhydrite, or shale. The salt cuttings in a well being drilled may go into solution in the water which is used in drilling or become mixed with mud, and thus may escape notice when bailed from the well. The driller probably would record salt when the contact between a hard bed, such as dolomite, above and thick salt bed below was sharp, for the bit would have a tendency to penetrate more easily when it reached the salt. Some drillers recorded from one to four beds of salt; in the same area others recorded the top of the uppermost salt bed and the bottom of the lowest salt bed and thus logged as salt the entire sequence of rocks, which in reality included also beds of dolomite, limestone, anhydrite, and shale.

The determination of the thickness of salt beds from an examination of samples taken through the salt series is difficult, for much of the salt is dissolved by the water used in drilling. Usually samples are taken at intervals of 6 to 10 feet, and

if only enough salt is present to saturate the water the samples may consist mostly of dolomite and anhydrite together with a few fragments of salt or salt crusts which are deposited upon the cuttings as the water evaporates. The beds represented by such a sample may thus consist mainly of salt, the dolomite and anhydrite being present only as thin beds. However, the presence of salt and an estimation of the thickness of the salt beds can be much more accurately determined from well samples than from the driller's log.

OCCURRENCE OF THE SALT

The oldest salt beds throughout the region of southern New York, western Pennsylvania, northern West Virginia, eastern Ohio, Michigan, and southwestern Ontario were deposited in local isolated basins. For example, the oldest salt beds in Ohio were deposited in the deeper part of a basin in Portage and Columbiana Counties. As deposition of salt continued, each basin increased in size until near the end of Salina time the basins became connected and salt was deposited throughout the region. Over a broad area in eastern Ohio some of the salt beds, although apparently nearly continuous by correlation based on position in the section, are probably not strictly equivalent in time of deposition.

The salt beds of the Ohio salt basin occur in the central part of a thick section of limestones and dolomites. The drillers call this sequence of beds the Big Lime, because the drilling characteristics of limestone and dolomite are not sufficiently different to distinguish one from the other and because the muds bailed from wells drilling in this sequence of rocks have a gray color similar to lime muds. Stratigraphically in Ohio the Big Lime includes from the top down, the Delaware limestone, Columbus limestone, and Detroit River dolomite (all Devonian); the Bass Island dolomite (Silurian); the "bed of rock salt with some shale and interbedded dolomite, all of which probably represent the Salina group"[5] (Silurian) and the dolomites of the Niagara limestone (Silurian). The limestones and dolomites have been described from outcrops west of the salt area, but the salt beds are known only from subsurface information. In eastern Ohio along the Pennsylvania border some of the subsurface beds are correlated with, and named after, beds that crop out in New York and Pennsylvania. Thus, the term "Onondaga limestone" is used in eastern Ohio to describe the Devonian limestone of the Big Lime above the salt. On paleontological evidence the Onondaga limestone at outcrops in New York and Pennsylvania is apparently equivalent only to the Columbus limestone.

The amount of shale in the salt series varies from place to place. Although much shale is recorded in the salt beds by the drillers, Lamborn found from his sample examination that much of the so-called shale is either very thin bedded argillaceous dolomite or limestone. Sample records are too few in the salt basin to indicate the area in which the greatest amounts of dolomite, anhydrite, and shale are interbedded with the salt, but in general these other rocks appear to increase in proportion eastward.

WESTERN LIMIT OF SALT DEPOSITION

The western limit of salt deposition in Ohio is shown by the zero thickness line on the maps (figs. 1, 2). In Medina, Wayne, and Holmes Counties, the location of this line is based upon the examination of the records of many wells. In these counties the zero line was drawn at places where more than 75 per cent of the well logs contained no record of salt. In Lorain and Tuscarawas Counties the zero line is less accurately determined because fewer well records were available. South of Tuscarawas County in Guernsey, Noble, and Washington Counties where very little information is available, the zero line is only approximate.

[5]Lamborn, R. E. Data on the thickness and character of certain sedimentary series in Ohio: Ohio Jour. Sci., vol. 34, no. 6, pp. 353–354, November, 1934.

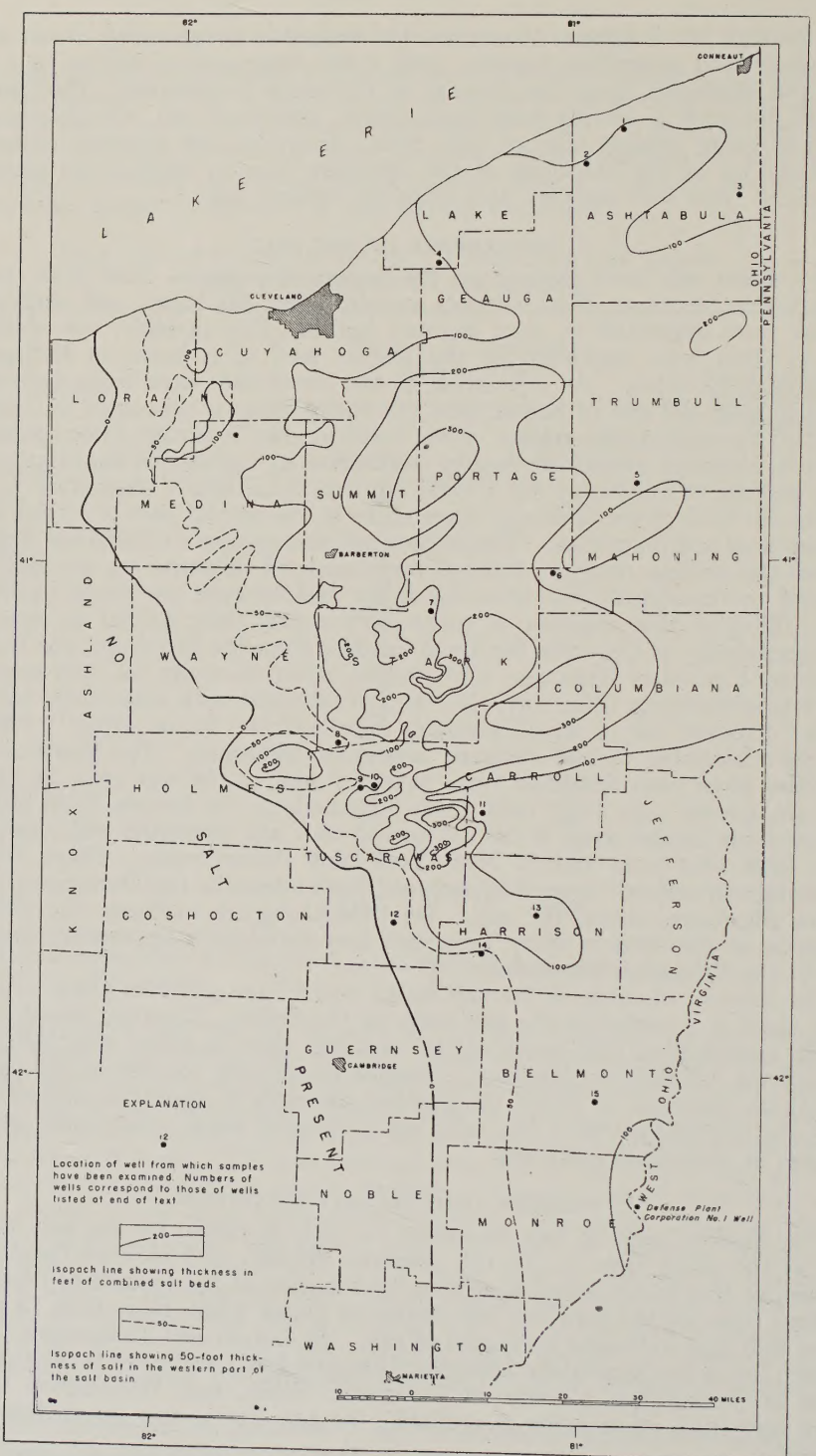

FIGURE 1. Salt thickness map. Shows the combined thickness of all known beds of salt within the Ohio salt basin.

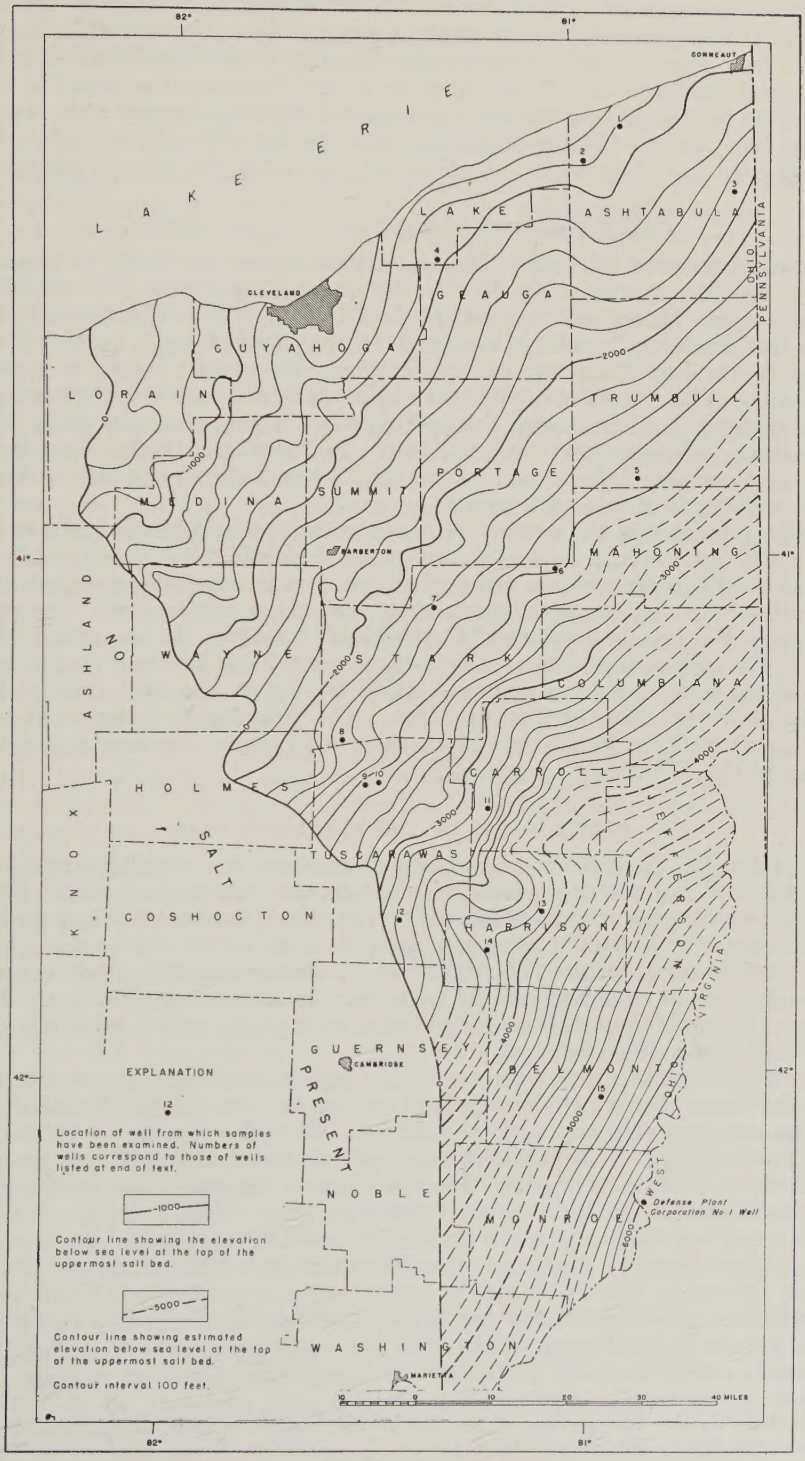

FIGURE 2. Map of eastern Ohio showing depth of the uppermost salt bed below sea level.

In the northwestern part of the salt basin, especially in Medina and Wayne Counties, the many well records show a gradual but irregular thinning of the salt beds from east to west. For example, in eastern Medina County the records show a total thickness of 100 feet or more of salt, but near the zero line the salt beds thin to between 5 and 20 feet. Possibly if sufficient sample logs were available, the zero line would show more irregularities, for probably the thin salt beds were deposited in embayments or shallow salt pans along the edge of the salt basin.

THICKNESS AND NUMBER OF THE SALT BEDS

The thicknesses of all known beds of salt within the salt basin have been combined on the thickness map (fig. 1). In the western part of the area shown on the map, in western Lorain and western Medina Counties, the driller usually records a single bed of salt; in Cuyahoga, eastern Medina, eastern Lorain, Summit, Portage, Geauga, Stark, and Tuscarawas Counties from two to four beds are recorded in many wells. The recording of but one thick salt bed in any but the westernmost of these counties is questionable, for probably in many of the wells shaly dolomite or anhydrite is interbedded with the salt. In Ashtabula, Lake, Trumbull, and Mahoning Counties, drillers record from two to five beds; in one well in Trumbull County eight beds of salt were recorded.

Whether the salt in the western part of the basin was deposited as a single bed which splits into several beds eastward is not determinable. Locally a bed may split, but for the most part the salt probably occurs as lenses deposited at different times and hence now lies at different levels within the salt section. For example, in western Portage and western Columbiana Counties an eastward thinning occurs in the rocks lying between the lowest recorded salt bed and the "Newburg," a brine-filled zone of porous dolomite which lies below the salt series and about 200 feet above the base of the Big Lime. The thinning of these rocks suggests that the salt beds to the east are older than salt beds to the west whose vertical distance to the "Newburg" is greater.

DEPTH TO TOP OF THE UPPERMOST SALT

The map (fig. 2) shows by means of contour lines the approximate elevations, below sea level, of the top of the salt within the salt-bearing area. The map is not strictly a structure map, for the top of the uppermost salt encountered in any well may not be at the same stratigraphic level as the top of the uppermost salt in wells in other areas. The difference in stratigraphic level between the top of the salt beds in widely separated wells may be as much as 100 feet. Locally, however, the top of the salt between adjacent wells in any area is probably accurate within half of a contour interval.

The shallowest depth at which salt may be obtained appears to be in an area in Lorain County that includes Sheffield and Avon Townships. There the depth from the surface to the top of the uppermost salt bed ranges from 1,275 to 1,350 feet. From this place the salt beds dip southeastward, about 30 feet per mile, to Barberton, in Norton Township, Summit County, where in the test well of the Columbia Chemical Division of the Pittsburgh Plate Glass Company, the uppermost salt bed lies 2,751 feet below the surface[6] or 1,706 feet below sea level. Fifty-four miles southeast of Barberton the Texas Company's E. A. Mizer No. 1 well in Stock Township, Harrison County, found the uppermost salt at 4,767 feet below the surface or 3,846 feet below sea level. Although wells drilled below the salt are uncommon in southeastern Ohio, the few available records show that the salt dips southeasterly between Barberton and the Ohio River at a fairly uniform

[6]Stauffer, C. R. The geological section at the limestone mine, Barberton, Ohio: Am. Jour. Sci., vol. 242, p. 259, May, 1944.

rate of about 50 feet per mile, for Martens[7] records the top of the salt at 6,724 feet below the surface or 6,035 feet below sea level in the Defense Plant Corporation's No. 1 well in Franklin district, Marshall County, West Virginia.

THICKNESS OF BEDS BETWEEN TOP OF BIG LIME AND TOP OF UPPERMOST SALT BED

According to Martens[8] the interval between the top of the Onondaga (Big Lime) and the top of the uppermost salt bed is apparently highly variable in Pennsylvania and West Virginia, and the irregularity of this interval is particularly noticeable in western Pennsylvania. Cross sections also show variations in the vertical distance between the top of the Onondaga limestone and the top of the uppermost salt bed in Ohio, but the variations apparently are not as great as in Pennsylvania. The greatest vertical distances between the top of the Big Lime and the top of the uppermost salt bed in Ohio are in Columbiana and Portage Counties; these distances decrease markedly to the west and to the northeast.

Lamborn[9] has shown that the Big Lime sequence in Ohio is thickest in a belt along the eastern edge of the State, for he notes: "The thinnest part of the Big Lime as recorded in well records is found in Scioto and Pike counties where it measures about 300 feet. It thickens rapidly to the east and northeast, however, for it reaches its maximum development in Ohio along the eastern edge of the state from Columbiana County south to Washington County. From central Columbiana County this series thins again to the north in the direction of Conneaut. The greatest thicknesses yet recorded in this state are 1,987 feet in the Reamer well located in West Township, Columbiana County, and 1,841 feet in the Knowlton well in Independence Township, Washington County." He further states that "the thickening of the Big Lime to the east is believed to occur chiefly in its middle portion."

A thickening of the Onondaga limestone at the top of the Big Lime sequence has been noted by E. E. Rehn.[10] The thickest belt of Onondaga limestone, as shown on his map, coincides with the thick Big Lime belt shown by Lamborn in Columbiana County.

Further evidence of a thickening of that part of the Big Lime that overlies the salt was noted by the present writer in cross sections and in the records of numerous wells in northeastern Ohio. This evidence is contingent on the assumption that the uppermost salt beds are of equivalent age over a wide area. If isolated beds of salt were deposited somewhat higher in the section than the average for other beds, there would be an apparent thinning of that part of the Big Lime above the salt. As an aid in testing this inference a map of the thickness of that part of the Big Lime above the salt series was constructed (fig. 3). The map brings out several striking features. Most noteworthy is the area of thick limestone trending slightly west of north from Columbiana County through Portage and Geauga Counties to Lake Erie. This belt approximates very closely the belt shown by Lamborn[11] in his thickness map of the Big Limestone sequence. East of the belt of thick lime the lime thins toward the Pennsylvania State line, and west of the belt the lime thins to a narrow area which extends from central Wayne County N. 25° W. across Medina County and into Lorain County. This area is enclosed by the 500-foot thickness contour on figure 3. West of the area enclosed

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[7]Martens, J. H. C. Rock salt deposits of West Virginia: West Virginia Geol. Survey Bull. 7, p. 15, 1943.

[8]Martens, J. H. C., idem, pp. 6–9.

[9]Lamborn, R. E., op. cit., pp. 353–355.

[10]Rehn, E. E. Onondaga group of parts of West Virginia and Virginia. Unpublished thesis, Ohio State University, 1942.

[11]Lamborn, R. E., op. cit., p. 354.

by the 500-foot contour the Devonian limestone and Bass Island dolomite increase in thickness to the western limit of the salt area. The interesting coincidence of the axis of the Parkersburg-Lorain syncline and the western edge of the thin area of Devonian limestone and Bass Island dolomite may be fortuitous or may indicate that the apparent westward thickening of the limestone is caused by the filling of a basin which was downwarped after the salt was deposited. If this

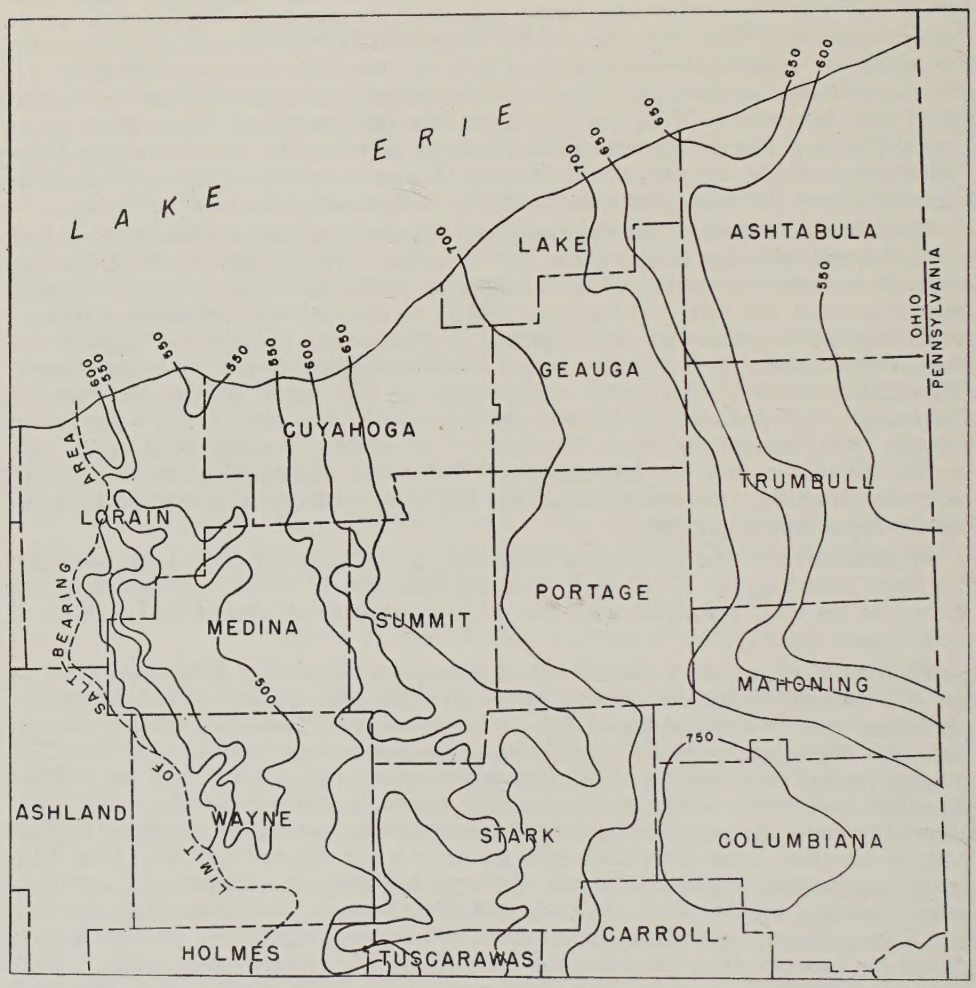

FIGURE 3. Map showing the variation in thickness of the rocks between the top of the Big Lime and the top of the uppermost salt bed. Contour interval 50 feet.

basin was present and a proportionately greater amount of limestone was deposited above the salt, then the thickness of the Big Lime which includes the limestones and dolomite above and the dolomites below the salt would be greater than the thickness of the Big Lime east of the basin. This is not true, however, for the

[12]Lamborn, R. E., op. cit., p. 354.

total thickness of the Big Lime is nearly the same as that shown on the thickness map by Lamborn,[12] which shows a gradual thickening of the Big Lime eastward. The thickening of the Devonian limestone and Bass Island dolomite above the salt may have been caused by subsequent erosion of the upper part of the salt section prior to the deposition of the Bass Island dolomite. Possibly, however, the apparent thickening is caused by the deposition of a salt bed low in the salt section and an absence of deposition of salt beds above at a later time.

When the thickness map of the upper Big Lime is compared with the thickness map of the combined salt beds, the areas of greatest thickness of each nearly coincide in Portage and Columbiana Counties. This relationship would seem to be reasonable proof that the deepest basin of deposition for the salt was likewise the deepest basin of deposition for the limestones above. The uppermost salt bed extends over a broad area and was deposited on an essentially flat surface.

THE LOCATION OF SALT PLANTS

The location of a salt plant depends largely upon the needs of the operator, who may desire a location near other chemical plants or along railroads that have the shortest haul to his markets. If the salt is not obtained by mining but is brought up as a brine from drilled wells, an adequate source of water is essential. Other factors permitting, the operator may desire the shallowest subsurface point in which he may obtain a maximum thickness of salt with a minimum of drilling.

A favorable area for prospecting for salt at a shallow depth lies in Lorain County. This area probably contains a sufficient thickness of salt in one bed to justify the cost of prospecting. If more than one bed of salt is required, then the areas of greatest salt thickness lying in Portage, Stark, and Tuscarawas Counties should be considered. Before a plant site is established and funds are expended for equipment and buildings, it would be prudent to make adequate core-drill tests of the salt series.

DESCRIPTION OF WELL SAMPLES BY R. E. LAMBORN

In the following records Lamborn has estimated the thickness of the salt beds from data derived from an examination of well cuttings. The writer made independent estimates of salt thicknesses from Lamborn's sample descriptions, and these estimates were in very close agreement with his. This agreement, however, may be a coincidence, for the determination of the thickness of a salt bed from well samples is at best an approximation. The thickness of a single salt bed was determined from an estimation of the percentage of salt fragments to other rock fragments in a sample taken at known depths, together with an estimation of the amount of salt taken into solution in the water used in drilling. Other factors considered were the size of the hole, the amount of water used in drilling, and the probable temperature of the water at the depth at which the sample was taken. Any of the factors used in determining the thickness of a salt bed from well cuttings may vary, and other and undeterminable factors may affect the calculations. For example, cavings from other formations, which may include higher salt beds, may change the percentage of salt to rock fragments in the sample, or the water used in drilling may be partly saturated by contact with salt from a bed higher in the hole. The estimated thicknesses of the salt beds have been added to the sample logs only as a possible aid to further prospecting. Samples taken by drill cores through the salt series will provide the only accurate means of determining the thickness of individual beds.

DESCRIPTIONS OF SAMPLES EXAMINED BY R. E. LAMBORN FROM SELECTED WELLS DRILLED THROUGH THE SALT

1. Ashtabula County — Saybrook Township — Lot 36
J. Q. Metcalf No. 1 — By Ohio Oil Company
Elevation 651 feet — Total depth 2930 feet — Completed in 1941
Located in Ashtabula quadrangle, 0.10 mile N. of 41° 50′ and 2.18 miles E. of 80° 55′

Depth (in feet) to Top	Bottom	*Description of sample*	*Estimated thickness of salt (feet)*
1370		Big Lime	
2052	2060	Rock salt, white	8
2060	2078	Rock salt, brownish	18
2078	2087	Dolomite, brown to gray, argillaceous	
2087	2096	Rock salt, brown	9
2096	2221	Dolomite, gray to bluish-gray, argillaceous, and dolomitic shales; some anhydrite	
2221	2234	Salt	13
2234	2255	Salt	21
2255	2268	20% salt; 80% shale	6
2268	2279	50% salt; 50% shale	8
2279	2288	Salt, nearly pure	9
2288	2304	Dolomitic shale and argillaceous dolomite with a few salt crystals	9
2304	2311	Shale, dark, and argillaceous dolomite; a few salt crystals	4
		Total	105

REMARKS: No salt observed in samples below depth of 2311 feet.

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2. Ashtabula County — Harpersfield Township — Lot 43
Breyley Bros. No. 1 — By Magnolia Petroleum Co.
Elevation 820 feet — Total depth 3341 feet — Completed in 1940
Located in Ashtabula quadrangle, 1.20 miles N. of 41° 45′ and 1.75 miles E. of 81° 00′

Depth (in feet) to Top	Bottom	*Description of sample*	*Estimated thickness of salt (feet)*
		Big Lime	
2200	2212	Dolomite, dark brown, impure, and dolomitic shale, trace of anhydrite	
2212	2230	Dolomite, dark brown, impure; a few percent of anhydrite and rock salt	9
2230	2250	Dolomite, brown; 25% salt and anhydrite	10
2250	2280	Rock salt, white	30
2280	2315	Dolomite, impure, and dolomitic shale; trace of anhydrite	
2315	2333	Dolomite, buff, porous, impure	
2362	2375	Dolomite, buff, porous, impure, and dolomitic shale	
2375	2385	Dolomite, brown, impure, and dolomitic shale; 30% rock salt	6
2385	2400	Dolomite, buff to brown, impure, a little anhydrite	
2400	2415	Same as above with 10% rock salt	9
2415	2464	Shale, brown to bluish-gray, dolomitic; trace of anhydrite	
2464	2477	Shale, greenish-gray, dolomitic, trace of brown impure dolomite and anhydrite	
2477	2552	Shale, greenish-gray and brown impure dolomite; trace of anhydrite	
2552	2569	Shale, light greenish-gray	
2569	2578	No sample	
2578	2600	Rock salt; a few fragments of dolomite	22
2600	2610	Rock salt	10
2610	2630	Dolomite, brown, dense; 5% anhydrite and rock salt	9
		Total	105

REMARKS: No salt observed in samples from greater depths in this well.

3. Ashtabula County — Richmond Township — Lot 15
Hatton Brothers No. 1 — By Ohio Oil Company
Elevation 1049 feet — Total depth 3841 feet — Completed in 1941
Located in Andover quadrangle, 3.55 miles S. of 41° 45′ and 3.74 miles W. of 80° 55′

Depth (in feet) to Top	Bottom	Description of sample	Estimated thickness of salt (feet)
2235		Big Lime	
2905	2928	Chiefly rock salt; a little dolomite	21
2928	2980	Shale, soft, bluish-gray, dolomitic, with anhydrite	
2980	3000	Limestone, light bluish-gray, dolomitic; no anhydrite	
3000	3049	Dark, bluish-gray, impure gypsiferous rock	
3049	3057	Dark-gray impure gypsiferous rock mass, caked by salt	3
3057	3135	Bluish-gray, gypsiferous rock with 5% to 10% rock salt	39
3135	3155	Dark bluish-gray, gypsiferous rock with a few salt crystals	5
		Total	68

REMARKS: No salt observed in samples at greater depths.

4. Lake County — Kirtland Township — Lot 90
F. O. Andrews No. 1 — By East Ohio Gas Company
Elevation 1090 feet (topographic map) — Total depth 3756 feet — Completed in 1940
Located in Mentor quadrangle, 0.25 mile S. of 41° 35′ and 1.00 mile W. of 81° 20′

Depth (in feet) to Top	Bottom	Description of sample	Estimated thickness of salt (feet)
1791		Big Lime	
*2523	2549	Dolomite, brown, impure, argillaceous, with anhydrite; 5% rock salt	13
2549	2561	Dolomite, brown, impure, with a small amount of anhydrite	
2561	2576	Rock salt	15
2576	2586	Dolomite, brown, impure; some anhydrite and rock salt	5
2586	2594	Dolomite, light-brown, impure, porous; with anhydrite	
2594	2602	Dolomite, light-brown, impure, porous; some crusting of salt	3
2602	2612	Dolomite, brown; 75% salt crystals	9
2612	2642	Dolomite, brown; 50% salt crystals	21
2642	2788	Dolomite, brown, argillaceous, with anhydrite	
2788	2797	Dolomite, brown, impure, argillaceous; 15% salt; some anhydrite	5
2797	2811	Dolomite, brown, impure, argillaceous; some anhydrite; 30% salt	7
2811	2855	Dolomite, brownish, argillaceous; some greenish-gray shale	
2855	2947	Same, with anhydrite	
2947	2960	Dolomite, brown, impure; 2% salt crystals	8
2960	2969	Dolomite, brown, impure; some salt and anhydrite	5
		Total	91

*Top of uppermost salt bed recorded by driller at 2534 feet.

5. Trumbull County — Lordstown Township — Lot 20
John Giovannone No. 1 — Magnolia Petroleum Company
Elevation 960 feet (topographic map) — Total depth 4824 feet — Completed in 1941
Located in Warren quadrangle, 1.0 mile S. of 41° 10′ and 0.40 mile W. of 80° 50′

Depth (in feet) to Top	Bottom	Description of sample	Estimated thickness of salt (feet)
2785		Big Lime	
3407	3422	Dolomite, dark bluish-gray and brown, argillaceous and gypsiferous, caked by salt	6
3422	3462	Dolomite, brown, impure, with some salt crystals	18
3462	3477	Dolomite, light-brown, impure, argillaceous, with anhydrite	
3477	3503	Same as above, with salt crystals	10
3503	3600	Dolomite, brown, argillaceous, much anhydrite	
3600	3612	Dolomite, brown, impure, porous, with anhydrite	

3612	3640	Dolomite, brown, porous, impure, with some salt	13
3640	3808	Dolomite, brown, dense, impure, argillaceous; with anhydrite	
3808	3838	Dolomite, brown, argillaceous, porous; with anhydrite	
3838	3862	Dolomite, with rock salt and anhydrite	14
		Total	61

REMARKS: No salt observed at greater depths.

6. Mahoning County — Smith Township — Section 4
T. S. Schrum No. 1 — By Magnolia Petroleum Company
Elevation 1064 feet — Total depth 5021 feet — Completed in 1941
Located in Alliance quadrangle, 1.7 miles S. of 41° 00′ and 2.78 miles W. of 81° 00′

Depth (in feet) to Top	Bottom	*Description of sample*	*Estimated thickness of salt (feet)*
2824		Big Lime	
3555	3570	Dolomite, impure; 85% salt crystals	13
3570	3607	Salt crystals	37
3607	3632	Dolomite, buff, argillaceous, with anhydrite	
3632	3680	Dolomite, buff, argillaceous; 5% rock salt	20
3680	3780	Dolomite, buff, argillaceous; trace of anhydrite	
3780	3815	Dolomite, buff, argillaceous; 10% salt crusts	10
3815	3820	Dolomite, buff to gray-black; trace of anhydrite	
3820	3835	No sample	
3835	3881	Dolomite, buff, argillaceous; 70% salt crusts	18
3881	3945	Dolomite, buff, dense, argillaceous; trace of anhydrite	
3945	3983	Dolomite, deep-buff and brown; argillaceous; 5% to 10% salt	15
3983	4044	Dolomite, dark-gray to buff, dense texture, argillaceous; trace of anhydrite	
4044	4062	Dolomite, gray to buff, argillaceous; 5% salt crusts	7
		Total	120

REMARKS: No salt observed at greater depths.

7. Stark County — Lake Township — Section 34
Jacob Hyler et al No. 1 — C. W. White
Elevation 1150 feet — Total depth 4584 feet — Completed in 1939
Located in Canton quadrangle, 0.80 mile S. of 40° 55′, and 1.35 miles W. of 81° 20′

Depth (in feet) to Top	Bottom	*Description of sample*	*Estimated thickness of salt (feet)*
2765		Big Lime	
3372	3382	Dolomite, brown, dense, with anhydrite	
3382	3391	Dolomite, brown, dense, with anhydrite; some salt crystals	5
3391	3402	Dolomite, buff, dense, 5% anhydrite	
3402	3413	Dolomite, buff, dense, 5% anhydrite, a little rock salt	5
3413	3436	Dolomite, buff, dense, with anhydrite	
3436	3448	Dolomite, buff, dense, with anhydrite; 50% rock salt	8
3448	3484	Rock salt, almost pure	36
3484	3495	Dolomite, buff, dense, with 50% anhydrite	
3495	3505	20% anhydrite and dolomite; 80% rock salt	10
3505	3515	Dolomite 50%; rock salt 50%	7
3515	3535	Dolomite, buff, 50%; some anhydrite and shale	
3550	3568	Dolomite, brown, dense, a little anhydrite and salt	9
3568	3578	Dolomite 50%; anhydrite and salt 50%	6
3578	3589	Dolomite 60%; anhydrite and salt 40%	6
3589	3600	Dolomite, buff; a little anhydrite and dark shaly dolomite	
3600	3690	Dolomite, buff, dense, small amount of anhydrite	
3600	3756	No salt recognized	
3690	3756	Dolomite, buff, impure, porous; trace of anhydrite	
3756	3766	Dolomite, buff, porous; some anhydrite, salt, and shale	4
3766	3778	Same as above, 50% salt and shale	5
3778	3790	Chiefly rock salt	12
		Total	113

REMARKS: No salt observed in samples at greater depth from this well.

8. Stark County — Sugar Creek Township — Section 34
M. Kaylor No. 1 — By Ohio Oil Company
Elevation 1005 feet — Total depth 4368 feet — Completed in 1943
Located in Navarre quadrangle, 1.55 miles S. of 40° 40′ and 0.85 mile W. of 81° 35′

Depth (in feet) to Top	Bottom	Description of sample	Estimated thickness of salt (feet)
2637		Big Lime	
3207	3264	Dolomite, buff, argillaceous; some anhydrite	
3264	3280	Dolomite, buff, argillaceous; some anhydrite; a few salt crystals	9
3280	3304	Rock salt	24
		Total	33

Remarks: No salt recognized at greater depths in this well.

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9. Tuscarawas County — Franklin Township — Section 9
George Smith No. 1 — By Columbian Carbon Company
Elevation 935.6 feet — Total depth 4477 feet — Completed in 1941
Located in Navarre quadrangle, 1.45 miles S. of 40° 35′ and 2.10 miles W. of 81° 30′

Depth (in feet) to Top	Bottom	Description of sample	Estimated thickness of salt (feet)
2859		Big Lime	
3498	3532	Rock salt 85%; 15% brown, impure dolomite	32
3532	3600	Dolomite, buff and brown, impure; with some shale; trace of anhydrite	
3600	3658	75% salt; 25% brown, impure dolomitic rock	49
3658	3666	Dolomite, buff, impure; trace of anhydrite	
3666	3675	Dolomite, buff to brown, porous; trace of anhydrite	
3675	3700	50% rock salt; 50% buff, impure dolomite and gypsiferous shale	17
		Total	98

Remarks: No salt recognized at greater depths.

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10. Tuscarawas County — Dover Township — Lot 30
Robinson Clay Products Co. No. 3 — By Brendel Producing Company
Elevation 900 feet (topographic map) — Total depth 4623 feet — Completed in 1940
Located in Navarre quadrangle, 1.15 miles S. of 40° 35′ and 0.20 mile W. of 81° 30′

Depth (in feet) to Top	Bottom	Description of sample	Estimated thickness of salt (feet)
2863		Big Lime	
3482	3490	Dolomite, buff, dense, with rock salt	5
3490	3502	Same as above; 60% rock salt	9
3502	3514	Dolomite, buff; some anhydrite with rock salt	5
3514	3529	Dolomite, buff; a little anhydrite	
3529	3545	Same as above; much rock salt	5
3545	3554	Dolomite, buff; porous, trace of anhydrite	
3554	3566	Dolomite, buff to brown, shaly; trace of anhydrite	
3566	3608	Dolomite, dark brown, dense texture; trace of anhydrite	
3608	3623	Chiefly rock salt; a little brown dolomite and anhydrite	15
3623	3638	Chiefly rock salt; a little brown dolomite and anhydrite	15
		Total	54

Remarks: No salt recognized at lower levels in this well.

11. Carroll County — Monroe Township — Section 9
S. W. Tipton et al No. 1 — By Brendel Producing Company
Elevation 948 feet — Total depth 5496 feet — Completed in 1941
Located in Carrollton quadrangle, 4.55 miles S. of 40° 35′ and 3.4 miles W. of 81° 10′

Depth (in feet) to Top	Bottom	*Description of sample*	*Estimated thickness of salt (feet)*
3540		Big Lime	
4130	4140	Rock salt, nearly pure	10
4140	4200	Dolomite, gray to dark-drab, argillaceous	
4200	4230	Same as above with 10% salt crusts	11
4230	4285	Dolomite, deep-buff to light-brown, dense, argillaceous	
4285	4290	Same as above, with 5% salt crusts	2
4290	4400	Dolomite, gray to dark-brown, dense, argillaceous	
4400	4405	No sample	
4405	4420	Dolomite, gray to dark-brown, dense, argillaceous; 20% salt cake	7
4420	4460	Dolomite, buff, dense, argillaceous	
4460	4470	Same as above; 5% salt cake	3
4470	4490	Dolomite, brown to buff, dense, argillaceous	
4490	4520	Same as above; with 50% salt crystals	22
4520	4540	Dolomite, brown, argillaceous; trace of salt	
		Total	55

Remarks: No salt recognized at greater depths in this well.

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12. Tuscarawas County — Clay Township — Section 22
Benjamin J. Carrothers No. 1 — By Ohio Fuel Gas Company
Elevation 1144.9 feet — Total depth 5289 feet — Completed in 1936
Located in Uhrichsville quadrangle, 1.92 miles S. of 40° 20′ and 2.58 miles W. of 81° 25′

Depth (in feet) to Top	Bottom	*Description of sample*	*Estimated thickness of salt (feet)*
3504		Big Lime	
4375	4390	Dolomite, brown; a little anhydrite; 20% rock salt	12
4390	4401	Same as above, small amount of rock salt	5
		Total	17

Remarks: No salt recognized at lower levels in this well.

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13. Harrison County — Stock Township — Section 32
E. A. Mizer No. 1 — By The Texas Company
Elevation 926 feet — Total depth 6301 feet — Completed in 1945
Located in Scio quadrangle, 1.40 miles S. of 40° 20′ and 0.75 mile W. of 81° 05′

Depth (in feet) to Top	Bottom	*Description of sample*	*Estimated thickness of salt (feet)*
4121		Big Lime	
4764	4802	Rock salt; 5% brown impure dolomite	35
4802	4826	Rock salt	24
4826	4859	Dolomite, gray to brown, argillaceous, with anhydrite	
4859	4894	Dolomite, buff to dark-brown, argillaceous, with salt cake	13
4894	4907	Dolomite, gray to gray-brown, dense, argillaceous, trace of anhydrite	
4907	4940	Dolomite, gray to brown, dense, argillaceous, some anhydrite; a few salt crystals	14
4940	4967	Same as above	11
4967	5002	Same as above	14
5002	5121	Dolomite, brown, dense, argillaceous, parts shaly; trace of anhydrite	

5121	5145	Rock salt, white; 3% impure dolomite	24
5145	5172	Rock salt 60%; 40% argillaceous dolomite	22
5172	5194	Shale, soft, brown; with anhydrite	
5194	5221	Dolomite, brown, argillaceous, trace of anhydrite	
5221	5276	Dolomite, brown, argillaceous, shaly; a few salt crystals; trace of anhydrite	26
5276	5287	Dolomite, brown; argillaceous, shaly; trace of anhydrite	
5287	5304	Dolomite, gray to light-buff, argillaceous; a few salt crystals	8
		Total	191

REMARKS: No salt recognized at greater depths in this well.

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14. Harrison County — Washington Township — Section 2
W. H. Blackwell No. 1 — By Ohio Oil Company
Elevation 1135 feet — Total depth 6255 feet — Completed in 1941
Located in Flushing quadrangle, 1.10 miles S. of 40° 15′ and 0.65 mile E. of 81° 15′

Depth (in feet) to Top	Bottom	*Description of sample*	*Estimated thickness of salt (feet)*
4230		Big Lime	
4836	4856	Salt, gray to buff; small percent of dolomite	20
4856	4865	Rock salt, nearly pure	9
		Total	29

REMARKS: No salt recognized at greater depths in this well; no salt recognized in samples above depth 4836.

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15. Belmont County — Smith Township — Section 19
T. H. Mobley — Natural Gas Company of West Virginia
Elevation 1174 feet — Total depth 7887 feet — Completed in 1940
Located in Clarington quadrangle, 3.35 miles S. of 40° 00′ and 2.50 miles W. of 80° 55′

Depth (in feet) to Top	Bottom	*Description of sample*	*Estimated thickness of salt (feet)*
5451		Big Lime	
6231	6254	Dolomite, dark-bluish, impure; sample encrusted with salt	7
6254	6313	Same as above with larger percent of rock salt	23
6313	6345	Dolomite, brown, impure, with a trace of salt	13
6345	6464	Dolomite, dark-brown, impure, and dolomitic shale; much anhydrite	
6464	6625	Dolomite, buff, impure, and dark dolomitic shale; much anhydrite	
6625	6647	Dolomite, dark brown, impure; some anhydrite; salt encrusted	7
6647	6655	Dolomite, light brown; dark brown dolomitic shale; some anhydrite	
6655	6662	Same as above; caked with salt	
6662	6687	Dolomitic shale, brown, gypsiferous, with some salt	10
6687	6695	Same, salt encrusted	3
6695	6701	Shales, buff, with anhydrite and some salt crusts	
6701	6809	Dolomite, buff, impure, and dolomitic shale; somewhat encrusted with salt	2
		Total	65

CHARACEAE OF THE PUT-IN-BAY REGION OF LAKE ERIE (OHIO)[1]

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During the summer of 1940, while a student at the Franz Theodore Stone Laboratory of the Ohio State University, the writer made a series of collections of the Characeae from the Put-in-Bay region of Lake Erie. Further collections were made during brief visits in 1941, at which time the entire shore line of the bay was dredged with "Nordstedt hooks"[3] in an attempt to rediscover several species previously reported by Pieters (1901). The determinations of the collections were recorded in a Master's Degree Thesis at Northwestern University (Wood, 1942). In 1946, the writer was able to compare his material with the original Pieters collections and with additional specimens in the New York Botanical Garden, and to review his original determinations in light of what had been learned through personal association with G. O. Allen of England.

The objective of the present paper is to present as workable a treatment as practicable to enable students of the Biological Station to determine the Characeae of the region. To attain this objective, the classical arrangement for such a work has been somewhat forfeited in the following ways: (1) the key which attempts to contrast differences in apparently similar species regardless of taxonomic relationships; and (2) the illustrations which, having been prepared in chart form with structures of similar species placed together and reproduced at the same magnification, enable ease in comparing and contrasting critical characters with a plant in hand. The terminology has, as far as possible, been stated in non-technical words with the technical terms inserted parenthetically.

The nomenclature, for the convenience of the student, follows that of T. F. Allen's *Characeae of America*, Part II (1892, '94, '96) for the Nitellas, and Robinson's *The Chareae of North America* (1906) for the Charas. This has been done because these works are the most usually available studies of the American forms. Deviations from this nomenclature, as indicated in recent monographic works, are noted in the discussion of each species.

Although the objective has aimed at clarification and simplification for student use, every attempt has been made to bring the fundamental data in accord with the most recent trends in the taxonomic literature of the Characeae.

THE REGION

The Put-in-Bay region is delimited in this study to an area including South Bass, Middle Bass, North Bass, and their adjacent islands, Catawba Point, and inland to the Blue Hole of Castalia. For a discussion of the region, the reader is referred to Tiffany (1937, p. 912).

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[2]The writer wishes to acknowledge with deepest sincerity the inspiration and aid of C. E. Taft of the Ohio State University in suggesting this problem. The gracious cooperation of F. J. Seaver and Rosalie Weikert, of the New York Botanical Garden, who made the vast collections of that institution available for study, was invaluable. He is deeply indebted to G. O. Allen, well-known English authority on Charophyta, for the hospitality, patience, and instruction during the writer's visits in the war years. The author especially acknowledges the encouragement and guidance of his adviser, L. H. Tiffany, of Northwestern University.

[3]Allen, T. F. Bot. Gaz. 12: 297, 1887.

COLLECTIONS AND LITERATURE

Apparently the only work on the Characeae of this region was published by Pieters (1901) in his *Plants of Western Lake Erie*, based on his collections in the area in 1898. The material was determined by T. F. Allen and Otto Nordstedt. In this study were reported 14 species, 1 variety, and 10 forms; and photographs of three species and two forms were included. Pieters' collection was deposited in the Cryptogamic Herbarium of the New York Botanical Garden (NY).[4] For over forty years no further publications on the Characeae of the region appeared.

The writer's collection of 1940 and 1941 was prepared in duplicate. A set was left at the Stone Laboratory, representative specimens of all species were deposited in the Cryptogamic Herbarium of the Chicago Natural History Museum (F), and the remaining specimens were retained in the writer's herbarium (RDW).

NOTES ON TERMINOLOGY

The terms stem, branches, leaves, rays, dactyls, leaflets, bracts, spines, stipulodes, and heads are employed because of their general usage in the taxonomic literature. They are in part useful in that they suggest similar structures in flowering plants. The *stem* refers to the primary vertical axis. *Branch* refers to the one or two vertical axes which arise in the center of a whorl of leaves. *Leaf* refers to one of the laterals in a whorl at a stem or branch node. *Ray* refers to one of the segments of a furcated leaf in Nitellas. *Dactyl* refers to one of the set of rays beyond the last furcation of a leaf in Nitellas. *Leaflet* refers to one-celled processes arising at the sterile modes of leaves. *Bract* refers to one-celled processes arising at the base of the sex organs. *Spine* refers to the one-celled processes arising along the stem from the cortical nodes in Charas. *Stipulode* refers to the one-celled processes forming one or two rings about the stem at the base of the leaves in Chara. *Head* refers to occasional dense semi-globular clusters of short leaves which occur on certain Nitellas and are characteristic of Tolypellas. In modern literature (Groves and Bullock-Webster, 1920, 1924; Zaneveld, 1940), the term branchlet replaces our usage of leaf, bract replaces leaflet, and bracteole replaces our term bract.

The sex organs have been long known in the literature as antheridia and oogonia. The name *antheridium* is applied to the spherical sex organ in which the spermatozoids originate. In the light of recent morphological concepts (Goebel, 1930), this term is a misnomer; the term antheridium is restricted in use to the individual spermatogenic cells of the capitular filaments within the spherical structure. Smith (1938, p. 131) employs the noncommittal and more descriptive term, globule. The name *oogonium* is applied to the female sex organ which is encased by spirally twisted enveloping cells and terminated by a coronula of five (*Chara*) or ten (*Nitella*, *Tolypella*) terminal cells at the abaxial end. Smith employs the equally noncommittal word, nucule, for this structure. Both globule and nucule have occurred in the literature from time to time; and as the antheridia and oogonia, as taxonomically employed, are in themselves misleading, Smith's usage is to be recommended. Numerous other authors have attempted to establish more morphologically consistent terms such as antheridiocarp and oogoniocarp, antheridium and sporangium, antheridium and sporocarp. However, to be consistent with the majority of the literature, the writer has retained *antheridium* and *oogonium* in the present work.

NOTES ON TECHNIQUE

A study of the Characeae will be greatly facilitated by good plant material in fertile condition. In our region the best collecting is done in June and July before silt deposition and epiphytes cover the specimens, and while most of the species are fertile. However, certain types of treatment will render most specimens determinable. Charas with heavy lime incrustation can be treated with dilute nitric or hydrochloric acid to remove the carbonate. If objectionable bubbles remain in the tissues, the plants can be boiled for a moment, or placed in water

[4]Abbreviations for herbaria as used in locality records for each species follow Lanjouw (1939), with the exception of the herbaria of R. B. Gordon (RBG) and the author (RDW).

and subjected to suction from an aspirator pump until cleared. Specimens covered with silt deposition or epiphytes can generally be cleaned by cautious wiping of critical structures to be studied.

For study collections, it is advisable to prepare both dry herbarium mounts for permanent record and preserve specimens in 4% formalin or some other algal preservative. For herbarium mounts, the plants are best floated out in a pan so as to assume a natural appearance. Mounting paper can then be slid under the specimen and the material cautiously lifted from the water so as not to disarrange the plant. The material can be covered with cloth, and dried between blotters. The cloth can then be carefully peeled off, leaving the plant attached to the paper. The writer routinely puts the wet specimens between folded newspaper instead of using cloths. Certain charas will not stick to the mounting paper, and in such cases a weak solution of mucilage can be used in place of water for floating out the specimens. If this latter method is employed, the use of cloths is almost required.

Microscopic study of the critical portions is generally essential, though with practice most local forms can be recognized at sight. Sex organs, though not obligatory in all cases, are essential in certain species such as *Chara Haitensis* and *C. compacta.*

In determining Charas the cortical cells along the stem are a major character to be studied. In order to determine the numerical relation between the corticating cells and the leaves in an adjacent leaf whorl, one may actually count the cells across a portion of the stem and the number of leaves in the whorl above or below, and decide whether the cortical cells are one, two, or three times the number of leaves in a whorl. In practice, however, one generally inspects the cortication and locates the primary cells by the presence of spines or nodal cells. Where these primary cells lie side by side, the number of cortical cells will be equal to that of the leaves in a whorl (*haplostichous*; no representatives in our flora, cf. *C. canescens* Lois.). Where a secondary cell lies between two such primary cells, the number of cortical cells will be twice that of the leaves (*diplostichous*, as in *C. contraria*, Plate III, fig. 3-A). Where two secondary cells lie between the primaries, the number of cortical cells will be three times that of the leaves in a whorl (*triplostichous*, as in *C. fragilis*, Plate III, fig. 4-A).

A second taxonomic character somewhat difficult to study is the presence or absence of cortication on the basal leaf internodal cell, especially since the stipulode ring at the base of the leaves may obscure these cells. However, under low power (100 *X*) one can separate the stipulodes and ascertain whether or not the cortication of the leaves extends completely to the base of the leaf (as in *C. fragilis*, Plate III, fig. 4-A), or whether it is interrupted by a clear portion—the naked base cell (*gymnopodous*, as in *C. Haitensis*, Plate IV, fig. 1-A, where two stipulodes are removed to show this cell). In practice one becomes accustomed to recognizing the apparently vacant space at the base of the leaves as indicating the gymnopodous condition rather than attempting to see the cells themselves. This appearance can often be recognized in the field.

The pattern of the oospore membrane is of diagnostic value especially in species of *Nitella*. This can easily be demonstrated by obtaining a *mature* oospore or oogonium, and crushing it gently under the cover glass on a slide in a drop of water. High dry objective (440 *X*) is generally adequate to make out the markings on the outer wall. In our species these patterns range from finely granular (*N. gracilis*, Plate I, fig. 2-E) to coarsely reticulate (*N. tenuissima*, Plate I, fig. 3-E).

KEY TO THE PUT-IN-BAY CHARACEAE

The following key should enable the student to determine all the local species in sterile or fertile conditions. The plates, which are arranged in nearly the same order as the key entries, can be conveniently used on questions of terms. In

essence, the plates form a pictorial key in themselves, and with little practice will replace rather than supplement the following presentation:

1. Stems smooth, not striated lengthwise (uncorticated) ..... (2)
1. Stems striated lengthwise (corticated) ..... (9)
   2. Leaves in whorls not forked or divided; spine-like stipulodes encircle the stem at the base of the leaves; antheridia occurring at the base of the oogonia ..... (8)
   2. Leaves in whorls usually one or more times divided or forked; without a circle of spine-like stipulodes at the base of the leaves; antheridia, if at the same node as the oogonia, then above or beside it, not at the base of it ..... (3)
3. Dense globular clusters of short, fertile leaves forming heads which are borne in center of whorls of elongated sterile leaves ..... (4)
3. Without globular heads; leaves similar throughout ..... (5)
   4. Heads 3–8 per plant, 2–3 (or more) cm. in diameter; tips of fertile leaves terminated by a series of short cells and a conically pointed tip ....5.[5] *Tolypella intertexta*
   4. Heads 20 or more per plant, up to 8 mm. in diameter; tips of fertile leaves not terminated by a series of short cells, the long dactyls narrowing to a point, 1. *Nitella subglomerata*
5. Tips of leaves narrowing to a point, not terminated by a small apical cell (mucro); fertile leaves clustered in small globular heads about 8 mm. in diameter, 1. *Nitella subglomerata*
5. Tips of leaves terminated by 1 or more minute apical cells; fertile leaves not clustered into heads ..... (6)
   6. The small apical cells of the leaves consisting of a single-celled mucronate tip (Plate I, fig. 2-A) ..... (7)
   6. At least some of the mucronate tips more than one-celled, varying from a single-celled mucro, to a mucro and a somewhat longer penultimate cell, to a 2–4–cuspidate crown (Plate I, fig. 4-A) ..... 4. *Nitella megacarpa*
7. Main stem axis not continuous throughout the plant, but branching frequently at nodes resulting in a diffuse type of growth; number of cells in the ultimate divisions of the leaves (dactyls, Plate I, fig. 2-B) varying from 2–3, of which the terminal cell is a small mucronate tip, and the lower 1 or 2 are elongated leaf cells ..... 2. *Nitella gracilis*
7. Main stem axis generally continuous throughout the plant, rarely appearing branched or diffuse, the whorls of leaves being regularly distributed along the stem; number of cells in the ultimate divisions of the leaves (dactyls) uniformly 2, of which the terminal cell is a small mucronate tip, and the lower an elongated leaf cell, 3. *Nitella tenuissima*
   8. Spine cells (bracts) arising from the base of the oogonia shorter than the oogonia (about one-half length of the mature fruit); leaflets at the sterile leaf nodes reduced to mere papillae, less than 2 times as long as wide, usually obscure, 6. *Chara Braunii*
   8. Spine cells arising from the base of the oogonia as long or longer than the oogonia; leaflets at sterile leaf nodes well developed, generally more than 3 times as long as wide, forming a circle of spines about each node of the leaf ... 7. *Chara Schweinitzii*
9. Leaves corticated with the exception of 1 or more terminal cells; the basal leaf cell always corticated; stipulodes either obscure or up to 3 times as long as wide, and in 2 rows, an upper and a lower series ..... (10)
9. Leaves either corticated or uncorticated, but in either case, the basal leaf cell is always uncorticated. If leaves corticated, the stipulodes more than 5 times as long as wide, and in two rows. If leaves uncorticated, the stipulodes long, but in only one row .... (12)
   10. Number of cortications of stem 2 times the number of leaves in an adjacent leaf whorl (diplostichous); stipulodes generally less than 2–3 times as long as wide ... (11)
   10. Number of cortications of stem 3 times the number of leaves in an adjacent leaf whorl (triplostichous); stipulodes obscure or merely papillae .... 10. *Chara fragilis*

[5]The numerals preceding the plant names correspond to their numbers in the text.

11. White bulbils generally present on rootlets; spine cells along the stem well developed on the upper internodes; stipulodes well developed, generally 2–4 times as long as wide; stem cortication irregular; antheridia and oogonia occurring on separate plants (dioecious) ..... 9. *Chara Macounii*

11. Without bulbils on rootlets; spine cells generally absent on stems, even on upper stem internodes, or if present, infrequent and very small; stipulodes rarely exceeding 2 times as long as wide, generally blunt; cortication regular; antheridia occurring at the base of oogonia at same leaf node (monoecious) ..... 8. *Chara contraria*[6]

12. Leaves uncorticated; stipulodes in one row; plants small, up to 10 or 15 cm. high ..... 11. *Chara Keukensis*

12. Leaves corticated, though the basal leaf internodal cell is always uncorticated; stipulodes in two well-developed rows, an upper and a lower series; plants up to 45 cm. or more high ..... (13)

13. Leaves straight, frequently exceeding 3 cm. in length; leaflets at sterile leaf nodes reduced to mere papillae; antheridia occurring at the base of oogonia[7], 12. *Chara Haitensis*

13. Leaves generally somewhat curved, rarely exceeding 2.5 cm. in length; leaflets at sterile leaf nodes forming a circle of spines about the node, regularly more than twice as long as wide; antheridia and oogonia occurring at different nodes of a leaf, or on different leaves of the same plant ..... 13. *Chara compacta*

Family **Characeae**

Subaquatic cryptograms with numerous chloroplasts per cell. Vegetative parts consisting of long internodal and short nodal cells, forming the stem and leaves. Leaves produced in whorls originating on the stem nodes. Sex organs borne on nodes of leaves. Sexual reproduction by means of biflagellate spiral-shaped antherozoids originating in the spherical male sex organ, and oospores borne in the female organ. Oogonium with envelope of five spirally arranged internodal cells, the apices of which form a coronula of small cells at the abaxial end of the oogonium. Germination gives rise to a protonema from which the plant sprouts as a lateral branch.

Tribe **Nitelleae**

Stems and leaves entirely without cortical cells. Branches similar to the main stem, two or more at a stem node, originating in the axils of the whorls of leaves. Leaves one or more times divided into one-celled rays, excepting the ultimate ray (dactyl) which may be more than one-celled. Cells of the coronula ten, in two superimposed series of five cells each.

Genus **Nitella**

Branches usually two at a stem node, opposite. Leaves one or more times furcate with more or less equal rays. Fertile leaves frequently contracted into heads. Antheridia terminal, in the furcations of the leaves, replacing the apical cell of a ray. Oogonia lateral at the leaf nodes, in monoecious species frequently just below the antheridia. Oospores laterally compressed.

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[6]Certain specimens collected by R. B. Gordon in 1946 have small spines which appear to arise from the furrows in dried specimens; or in which the secondary cortical cells are more prominent than the primaries. These fall within the definition of *Chara vulgaris* L. *pro parte* (cfr. *C. contraria*, in text).

[7]In deciding this character, if any antheridia occur with the oogonia, the plant is *C. Haitensis*. Frequently oogonia occur without the accompanying antheridia. In *C. compacta*, on the other hand, antheridia never occur at the same node as the oogonia. The presence of an isolated antheridium will strongly suggest *C. compacta*, but an isolated oogonium is not significant.

1. **Nitella subglomerata** Braun,[8] Monatsb. K. Akad. Wiss. Berlin, 1858, p. 356, 1858.

Allen, Char. of Amer. II, Fasc. I, p. 7, 1892. Daily, Butler Univ. Bot. Studies, 6: 151, 1944. Woods, Fl. Nebraska, p. 123, 1894.

N. acuminata var. *subglomerata* Braun, Abh. K. Akad. Wiss. Berlin, 1882, p. 36, 1883. Allen, Bull. Torrey Bot. Club, 2(3): 9, 1871.

Plate I, Fig. 1

Plant monoecious, varying up to 15 or 20 cm. high; slender and fragile in habit. Leaves 6–8 in a whorl, 3–4 times furcate. Terminal rays of leaves narrowed to an acuminate point, one-celled. Fertile leaves contracted into somewhat globular heads about 8 mm. in diameter. Oogonia and antheridia aggregated. Oospores 260–270 μ long, showing about 6 striations; oospore membrane granular without rounded tubercles. Antheridia 270–360 μ in diameter.

In our flora this species is distinct in that it is the only *Nitella* which has terminal rays beyond the last division of the leaf consisting of only one large cell; i.e., not terminated by a mucronate tip.[9] *Tolypella intertexta* is somewhat similar in appearance since both it and *N. subglomerata* form globular heads. However, the number of such heads in *T. intertexta* is only one or two at a node, and these heads are well over 15 mm. in diameter. The heads of *N. subglomerata*, when present, are very abundant, up to 8 per nodal whorl, and each is about 8 mm. in diameter. Further, the fertile leaves of *T. intertexta* have terminal segments of several cells in contrast to the single-celled dactyls of *N. subglomerata*.

Illustrations: Allen, 1892, unnumbered plate; Woods, 1894, plate XXV.

Localities: Lake Erie—*A. J. Pieters a-25*, 1898 (NY); East Harbor—*A. J. Pieters a-55*, 1898 (NY).

2. **Nitella gracilis** (Smith) Agardh, Syst. Alg., p. 125, 1824.

Allen, Char. of Amer. II, Fasc. III, p. 23, 1896. Halsted, Proc. Bost. Soc. Nat. Hist. 20: 176, 1879. Braun, Abh. K. Akad. Wiss. Berlin, 1882, p. 58, 1883.

Chara gracilis Smith, Eng. Bot. pl. 2140, 1810.

Plate I, Fig. 2

Plant monoecious, varying up to 20 cm. high; stems very slender. Leaves 5–6 in a whorl, 2–3 times furcate; ultimate rays beyond the last division 2–3-celled, the apical cell being a very short mucronate tip, and the penultimate cell tapering toward the terminal tip. Oogonia and antheridia not aggregate, occurring at each furcation of the leaves. Oospore 250–300 μ long, showing about 6 rather prominent ridges. Oospore membrane finely granular. Antheridia about 300 μ in diameter.

The writer has been unable to verify this record, as the only specimen recorded for this locality was apparently on loan at the time of his visit to the New York Botanical Garden. Pieters (1901) listed this species as "*N. gracilis* Ag. *vel sp. affinis*," so that at best it remains a doubtful record.

Nitella gracilis differs from *N. tenuissima* in its diffuse habit, in its finely granular oospore wall, and by the cells of the dactyls which vary from 2–3 cells.

Illustrations: Allen, 1896, unnumbered plate; Groves and Bullock-Webster, 1920, pl. 13; Migula, 1925, p. 214, and 1897, p. 161.

Localities: Upper Sandusky Bay—*A. J. Pieters 64*, 1898 (NY). (Not seen by the writer.)

3. **Nitella tenuissima** (Desv.) Kützing, Phyc. Gener. p. 319, 1843.

Braun, Abh. K. Akad. Wiss. Berlin, 1882, p. 62, 1883. Halsted, Proc. Boston Soc. Nat. Hist. 20: 177, 1879. Allen, Char. of Amer. II, Fasc. II, p. 24, 1896.

Chara tenuissima Desvaux, Journ. de Bot. 2: 313, 1809.

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[8]Recent monographers, including Groves (1911, p. 32), Braun (1883, p. 36), Zaneveld (1940, p. 61), cite this species as *N. acuminata* var. *subglomerata* Braun.

[9]*Nitella flexilis* (Sm.) Ag., which should be anticipated in this vicinity, has acute or obtuse instead of acuminate dactyls.

Plate I, Fig. 3

Plant monoecious, varying up to 15 cm. high. Leaves 6–8 in a whorl, 3–4–times divided; ultimate rays beyond the last division invariably 2-celled, the apical cell being a very short mucronate tip, and the penultimate cell an elongated leaf cell not much broader than the base of the apical cell. Oogonia and antheridia at the second and third leaf node (not at first furcation). Oospores 200–250 μ long, showing 7–8 fine, low striations. Oospore membrane strongly reticulate, though at times beaded-reticulate. Antheridia about 175 μ in diameter.

Pieters (1901) reported this species as *N. batrachosperma* from East Harbor. The writer was able to see the specimen, and concurs with Nordstedt's determination that it is identical to *N. tenuissima*.

This species is particularly graceful in its long continuous central axis upon which are borne small, tight whorls of leaves at regular intervals, giving somewhat the appearance of a series of balls distributed along the stem. Its regular straight habit of growth separates it from *N. gracilis*, even in the field. The uniformly 2-celled terminal rays beyond the last leaf division, strongly reticulate oospore membrane, and the absence of sex organs at the first leaf division further distinguish it from *N. gracilis*.

Illustrations: Allen, 1896, unnumbered plate; Groves and Bullock-Webster, 1920, pl. 14; Migula, 1897, p. 176, and 1925, p. 217.

Localities: East Harbor—*A. J. Pieters a-27*, 1898 (NY) as *N. tenuissima*; and *A. J. Pieters a-27½*, 1898 (NY) as *N. batrachosperma*, redet. *N. tenuissima*, *fide* Nordstedt.

4. **Nitella megacarpa**[10] Allen, Char. Amer. Exsicc. No. 3, 1880.

Nitella microcarpa subsp. (*N. megacarpa* Allen), Nordstedt *in* Braun, Abh. k. Akad. Wiss. Berlin, 1882, p. 73, 1883.

Nitella intricata Halsted, Proc. Boston Nat. Hist. Soc. 20: 178, 1879, according to Nordstedt *in* Braun, Abh. K. Akad. Wiss. Berlin, 1882, p. 73, 1883.

Nitella polyglochin Braun *sensu latiore*, subsp. *megacarpa*, Allen, *loc. cit.*

Plate I, Fig. 4

Plant monoecious, varying up to about 40 cm. high. Leaves about 6 in a whorl, 4-times divided; ultimate rays (dactyls) in two parts, including the small mucronate tip and the lower, large penultimate cell. The mucronate tips varying from single-celled mucros, to mucros with a penultimate cell, to a 2–4–cuspidate crown (Plate I, fig. 4-A). Oogonia and antheridia occurring at the nodes of the leaves, frequently isolated. Oospores 400–530 μ long, showing about 7 broad, low striations. Oospore membrane of irregularly distributed rounded tubercles, varying into a reticulate pattern, and in many cases coalescing into a continuously beaded or smooth reticulation. Antheridia about 400 μ in diameter.

This plant was reported by Pieters (1901) as *N. polyglochin*, but the specimen is identical to Allen's type of *N. megacarpa*.

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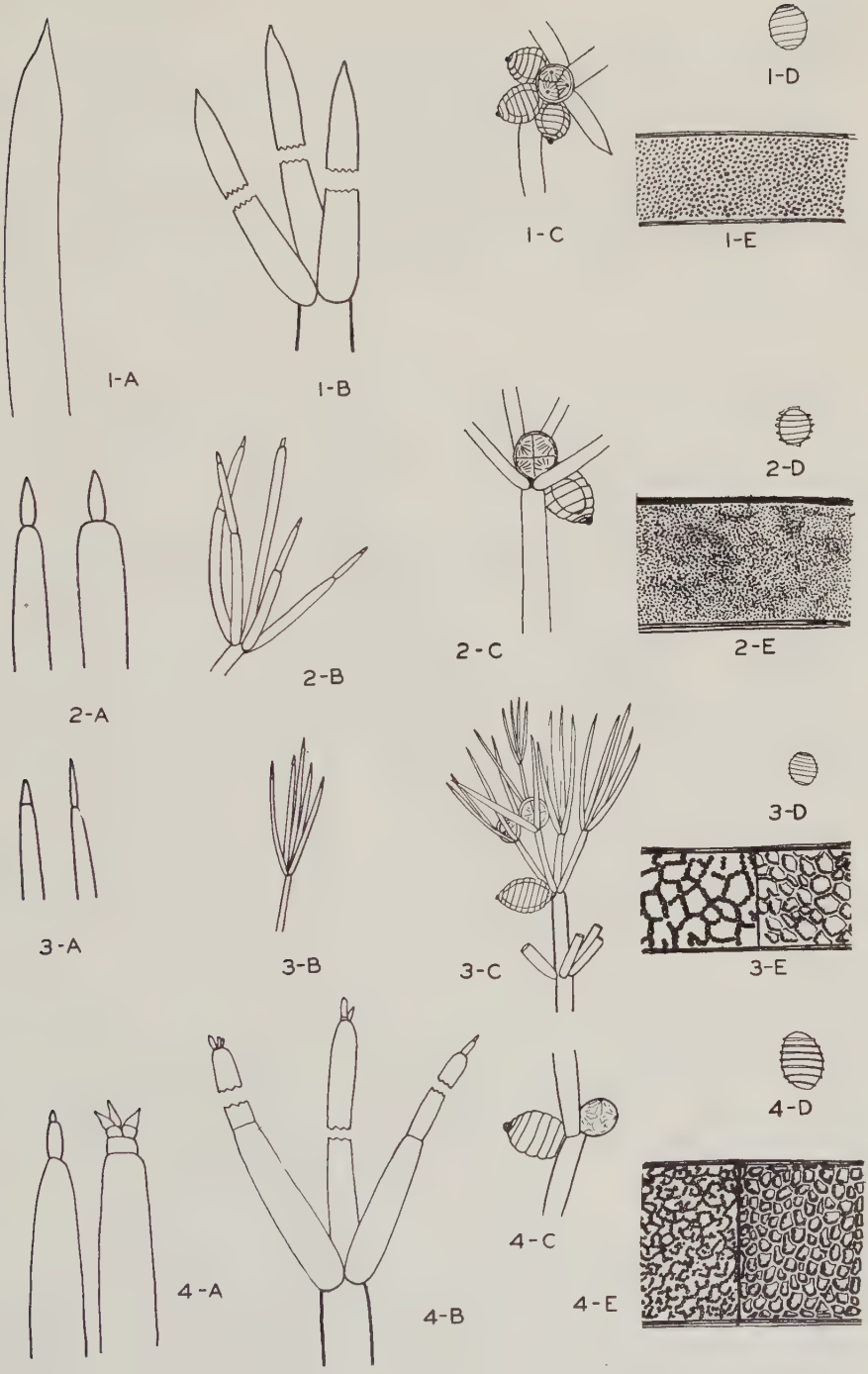
[10]Just what Allen intended to mean by his description: "*N. megacarpa Nov. sp.*—subsp. *N. polyglochin* Braun *sensu latiore*," is not clear. This is particularly awkward as Allen (1888, p. 47) made a subgeneric section "brachy-dactylae" as equivalent to "*N. polyglochin* A. Br. in its broadest sense." Based upon this fact, and upon the definite "*Nov. sp.*," the writer has retained *N. megacarpa* in this paper.

Zaneveld (1940, p. 103) includes *N. polyglochin* Braun, *in sensu latiore*, under *N. microcarpa* var. *microglochin* (Braun) Zanev. in a new combination. If this is substantiated, Allen's *N. megacarpa* will be reduced to a form of var. *microglochin*, or included as a synonym.

EXPLANATION OF PLATE I

FIGS. 1–4. In each case *A*. refers to terminal cell of leaf, × 40; *B*. dactyls, × 20; *C*. fruiting leaf, × 20; *D*. oospore, × 20; *E*. a portion of the oospore membrane between two striations, × 220 (in figs. 3-E and 4-E, two phases of pattern shown). Fig. 1. *Nitella subglomerata* Braun (1-A through 1-D after Allen, 1-E after Woods). Fig. 2. *N. gracilis* (Sm.) Ag. (after Groves and Bullock-Webster). Fig. 3. *N. tenuissima* (Desv.) Kütz. (3-A, 3-B, 3-E after Groves and Bullock-Webster; 3-C, 3-D after Migula). Fig. 4. *N. megacarpa* Allen (camera lucida drawings from No. 3, Characeae Americanae Exsiccatae, author's herb.).


1-A
1-B
1-C
1-D
1-E
2-A
2-B
2-C
2-D
2-E
3-A
3-B
3-C
3-D
3-E
4-A
4-B
4-C
4-D
4-E

In the field, the broad clumps of leaves give somewhat the appearance of a *Myriophyllum* or *Utricularia*.

Illustrations: None.

Exsiccatae: Allen, Char. Amer. Exsicc. No. 3, 1880.

Localities: East Harbor—*A. J. Pieters a-26*, 1898 (NY), as *N. polyglochin*.

Genus **Tolypella**

Branches usually more than two to a stem node. Sterile leaves simple or divided; fertile leaves furcate with very unequal rays, normally forming dense heads. Antheridia and oogonia usually long-stalked. Antheridia solitary, lateral at the nodes of the leaves or at base of leaf whorls. Oogonia always aggregated. Oospores subglobose.

5. **Tolypella intertexta** Allen, Bull. Torrey Bot. Club, 10: 115, pl. 42, 1883.

Plate II, Fig. 1

Plant monoecious, varying up to 50 cm. high. Sterile leaves 8 in a whorl, divided toward the apex into 3 or 4 rays. Fertile leaves densely contracted into heads situated in the vortex of the whorls of sterile leaves, 2- (rarely 3-) times divided. Oogonia aggregated at the fertile leaf nodes. Oospore 450–475 μ long, showing 10 acute striations. Antheridia short-stalked, about 380 μ in diameter, borne laterally at the fertile leaf nodes.

This species is readily distinguished from the Nitellas by the large, dense heads of fertile leaves amid the whorls of long sterile leaves. *N. subglomerata* has somewhat this appearance (cfr. *N. subglomerata*), but this character is not apparent in the field in contrast to the striking "birds-nest" appearance of *T. intertexta*.

Pieters (1901) reported this plant for the region: "Occurs in Hatchery Bay, but the plants are nowhere thrifty." In 1941, the writer dredged the entire shore of Put-in-Bay, which includes Hatchery Bay, in an unsuccessful attempt to recover this species. Pieters stated further: "In some spots an abundance of *Chara contraria* was found with a trace of *C. coronata* and *Tolypella intertexta*, but there are but few Characeae in Put-in-Bay. In the deeper parts of Lake St. Clair, *Tolypella intertexta* covers the bottom with a luxuriant growth, but in Put-in-Bay this species is scarce and the plants are small."

Illustrations: Allen, 1883, pl. 42; 1888, p. 50.

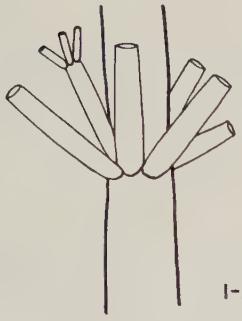
Localities: Hatchery Bay—*A. J. Pieters a-1*, 1898 (NY); in Put-in-Bay, west arm near U. S. F. Commission Hatchery. In about 10–15 feet of water—*A. J. Pieters a-1*, 1898 (NY). Note: Both specimens apparently from same collection, but occur on different sheets with different collection data, but with same number, *a-1*.

Tribe **Chareae**

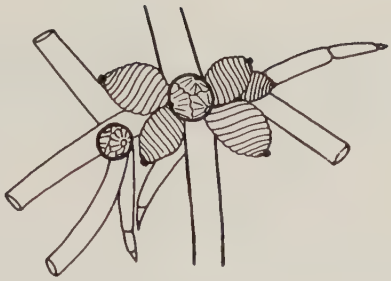
Plants with or without lime incrustation. Stem and leaves with or without cortical cells. Branches similar to the main stems, usually one at a stem node in the axil of the oldest leaf. Leaves 6–16 in a whorl at each stem node, not furcate, with one-celled leaflets at the leaf nodes (reduced to mere cells in certain species). Stipulodes at the base of the leaves in a double or single row, or rudimentary. Cells of the coronula in a single row of five cells.

EXPLANATION OF PLATE II

FIGS. 1–3. In each case *A.* refers to stem node, showing stipulodes in figs. 2-3, × 20; *B.* fruiting leaf nodes, × 20; *C.* terminal cells of leaf, × 20; *D.* leaflets at sterile leaf node, × 20. Fig. 1. *Tolypella intertexta* Allen (1-A, camera lucida drawing from *Pieters a-1* (NY), 1-B through 1-D after Allen). Fig. 2. *Chara Braunii* Gmelin (1-A through 1-C after Groves and Bullock-Webster; 1-D camera lucida drawing from *R. D. Wood 106* (F)). Fig. 3. *C. Schweinitzii* Braun (1-A, 1-C after Woods; 1-B after Allen; 1-C camera lucida drawing from *J. Gray 1* (RDW)).



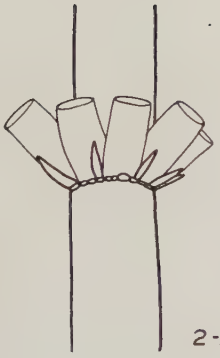
1-A



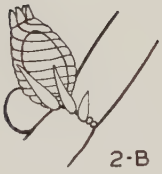
1-B

1-C

2-C



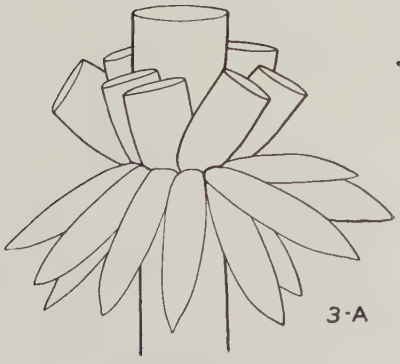
2-A



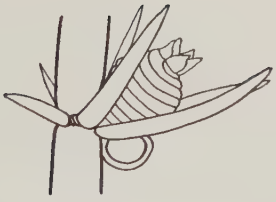
2-B

2-D

3-C



3-A



3-

3-D

Genus **Chara**

Stems and leaves corticated or uncorticated. Stipulodes always present, sometimes rudimentary. Leaves consisting of 5–14 articulations. Leaflets 5–7, the posterior (abaxial) ones frequently reduced. In monoecious species, antheridia and oogonia either borne at different leaf nodes, or the antheridia at the base of the oogonia.

6. **Chara Braunii**[11] Gmelin, Fl. Bad. 4: 646, 1826.

Robinson, Bull. N. Y. Bot. Gard. 4: 258, 1906.

Chara coronata Ziz. (*ined.*, *c. annum* 1814) Braun, Ann. Sci. Nat., ser. II, 1: 353, 1834. Allen, Amer. Nat. 16: 358, 1882. Daily, Butler Univ. Bot. Studies, 6: 155, 1944; *ibid.* 7: 129, 1945.

Plate II, Fig. 2

Plant monoecious, varying up to 20 cm. high. Stems and leaves sometimes partly incrusted with lime, totally uncorticated. Leaves 10–12 in a whorl. Stipulodes at the base of the leaves in one series, alternating with the leaves, and generally spreading. Bract cells at the base of the oogonia shorter than the mature oogonia. Leaflets of the sterile leaf nodes rudimentary. Oogonia and antheridia borne together at leaf nodes, antheridia at base of oogonia. Oospore 520–600 μ long, showing 7–9 striations. Antheridia 250–275 μ in diameter.

Allen (1882b) made a detailed study of the American forms of *C. coronata* (= *C. Braunii* Gm.), and concluded that the species was so polymorphic with intergradations that to attempt to describe specific forms was impractical. In collections of plants from the Put-in-Bay region this conclusion is well demonstrated, as forms intergrading between this species and *C. Schweinitzii* occur regularly. Zaneveld (1940), however, reviewed the species critically, and concluded that *C. Braunii* could be separated into six distinct varieties. The *C. Braunii* of the Put-in-Bay region would agree with *C. Braunii* var. *Braunii*, and our *C. Schweinitzii* with *C. Braunii* var. *Schweinitzii*. In both cases, the writer was able only to assign the various local intergrades either to one or the other species as approaching *C. Braunii* or *Schweinitzii*. Certainly, the recent monographic works which unite these forms into one species have taken the step in the right direction.

The fact that this species is absolutely uncorticated throughout frequently results in its being mistaken for a *Nitella*. However, the presence of stipulodes at the base of the leaves immediately separates it from *Nitella* and *Tolypella*. *C. Braunii* differs from *C. Schweinitzii* in having the leaflets at the sterile leaf nodes rudimentary instead of forming a ring of spines, and by the bracts at the base of the oogonia shorter in length than the mature oogonia.

Illustrations: Groves and Bullock-Webster, 1924, pl. 26; Woods, 1894, pl. XXX, fig. 1, 4, labeled *C. coronata;* Migula, 1925, p. 226, and 1897, p. 324, both labeled *C. coronata*.

Localities: Put-in-Bay—*A. J. Pieters a-23*, 1898 (NY) as *C. coronata, microptila, incrustata;* East Harbor—*A. J. Pieters a-41*, 1898 (NY) as *C. coronata;* Carp Pond, East Harbor—*A. J. Pieters a-42*, Aug. 10, 1898 (NY) as *C. coronata;* Just S. W. of Gibralter Laboratory dock along Alligator Bar, 3–5 foot littoral over grave'—*R. D. Wood 106*, Aug. 27, 1941 (F).

7. **Chara Schweinitzii**[12] Braun, Ann. Sci. Nat., ser. II, 1: 353, 1834.

Robinson, Bull. N. Y. Bot. Gard. 4: 249, 1906.

Chara coronata Schweinitzii Braun, Flora 18: 60, 1835.

Chara coronata Ziz. Braun, in part. Daily, Butler Univ. Bot. Studies, 4: 156, 1944.

Chara coronata forma *macrocarpa, meioptila, verticillata, tenuior, leiopyrena* Allen, Amer. Nat. 16: 364, 1882.

Chara coronata forma *macrocarpa, macroptila, verticillata, laxior, leiopyrena* Allen, *ibid.* p. 365.

Chara coronata forma *meiocarpa, microptila, unilateralia, laxior* Allen, *ibid.* p. 366.

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[11]Zaneveld's (1940, p. 141) classification includes our specimen in his combination *Chara Braunii* var. *Braunii* (Braun) Zanev. forma *typica* Zanev. The frequent use of *C. coronata* Braun (1834) must be considered a later homonym of *C. coronata* Bischoff (1828), and both later homonyms of *C. Braunii* Gmelin (1826).

[12]Zaneveld (1940, p. 139) cites this species as *C. Braunii* var. *Schweinitzii* (Braun) Zanev.

Plate II, Fig. 3

Plant monoecious, varying up to 150 cm. high (in our region usually less than 30 cm. high). Stems and leaves sometimes partly incrusted with lime. Leaves 8–11 in a whorl. Leaflets at sterile leaf nodes forming a ring of small spines about each node. Stipulodes at the base of the leaves alternating with the leaves, in one row, and generally spreading. Bract cells at the base of the oogonia 1½–3 times as long as the mature oogonia. Antheridia at the base of the oogonia at the leaf nodes. Oospores 520–650 μ long, showing 9–11 striations. Antheridia 280–320 μ in diameter.

In our region specimens frequently show in the field a banded mottled effect due to incrustation of lime across the leaf node. This is very obvious even when seen from a boat. Many plants form a bushy rather than attenuated growth in quiet, shallow water. It can generally be separated from *C. Braunii* by the ring of leaflets at the sterile leaf nodes, and the bract cells which are 1½–3 times as long as the mature oogonia (cfr. *C. Braunii*).

Illustrations: Allen, 1882b, p. 364, fig. 5, and p. 366, fig. 7; Woods, 1894, pl. 30, fig. 2, 5, 6, and 7, labeled *C. coronata*.

Localities: Fisher's Pond—*J. Gray 1*, Aug. 7, 1940 (RDW), *3*, *4* (F); Fisher's Pond—*G. Marguard 5*, Aug., 1940 (RDW); in first embayment west of Erie Isle Dock, South Bass, protected 2 feet of water—*R. D. Wood 109*, Aug. 27, 1941 (F) as *C. contraria*, but includes mostly *C. Schweinitzii;* Shallow water in embayment east of Oak Point in Squaw Harbor, Put-in-Bay—*R. D. Wood 110*, Aug. 27, 1941 (F) as *C. contraria*, but includes mostly *C. Schweinitzii;* East Harbor—*A. J. Pieters a-32*, 1898 (NY) as *C. coronata, meiocarpa, meioptila;* Squaw Harbor—*A. J. Pieters a-74* (NY) as *C. coronata* f. *incrustata*.

8. **Chara contraria** Braun *ex* Kützing,[13] [14] Phyc. Germ. p. 258, 1845.

Halsted, Proc. Boston Nat. Hist. Soc. 20: 187, 1879. Robinson, Bull. N. Y. Bot. Gard. 4: 265, 1906. Woods, Fl. Nebraska, p. 126, 1894. Daily, Butler Univ. Bot. Studies, 6: 158, 1944; *ibid.* 7: 127, 1945.

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[13]The author citation "Braun *ex* Kützing" apparently has not appeared in the literature. In Kützing's description, the name appears as "*C. contraria* Braun." Our usage thus indicates that Braun did not validly describe the species; but in describing it, Kützing ascribed the new species to Braun (cfr. International Rules, Art. 48 (1935)).

[14]Since the completion of the manuscript, the collections of R. B. Gordon have brought to the attention of the writer certain specimens which show features generally attributed to *C. vulgaris* L. As the intergradations between these aulocanthous forms and typical tylacanthous *C. contraria* seem to make a clear-cut differentiation impossible, the author has decided to include these aberrants in *C. contraria* to which the vast majority of the local specimens clearly fall. An analysis of *C. vulgaris* with the aberrant specimens seen is given herewith.

Chara vulgaris Linnaeus, Spec. Plant., 2: 1156, 1753, *pro parte*.

C. foetida Braun, Ann. Sci. Nat., ser. II, 1: 354, 1834.

Plant monoecious, varying up to 50 cm. or more high. Leaves 7–9 in a whorl, frequently with 2 or more uncorticated terminal cells. Stipulodes at the base of the leaves in two rows, short and blunt, generally well developed. Spine cells on internodes of stem appearing to arise from furrows between the ridges (aulocanthous, a feature especially noticeable in dried specimens), usually mere papillae. Corticating cells of stem twice the number of leaves in an adjacent leaf whorl, quite regular in pattern. The secondary cortical cells more prominent than the primaries. Antheridia at base of oogonia at same node. Oospores golden-brown to dark brown, ellipsoid or ellipsoid-cylindrical, 425–675 μ long, showing 12–15 low striations. Antheridia 325–500 μ in diameter.

This species is separated from *C. contraria* primarily by the aulocanthous cortication in which the secondaries are more prominent than the primaries. In *C. contraria*, the primaries are more prominent than the secondaries (tylacanthous); and in dried specimens the spine cells or cortical nodes appear on the ridges.

Illustrations: Groves and Bullock-Webster, 1924, pl. 28; Migula, 1897, p. 560, and 1925, p. 235.

Localities: Marl Pit, Castalia, Erie County—*R. B. Gordon* **1**, Aug. 7, 1946 (RBG); Blue Hole, Castalia, Erie County—*N. B. Green* **4**, Aug. 18, 1946 (RBG); *R. B. Gordon* **4**, Aug. 18, 1946 (RBG); Miller Blue Hole, Sandusky County—*R. B. Gordon* **6**, June 28, 1946 (RBG). (These specimens are also cited under *C. contraria* above.)

Plate III, Fig. 3

Plant monoecious, varying up to 50 cm. or more high. Leaves 6–10 in a whorl, with 2 or more uncorticated terminal cells. Stipulodes at the base of the leaves in two rows, short and blunt, occasionally greatly reduced. Spine cells on internodes of stem usually rudimentary, but occasionally short spines occur on the upper stem internodes. Corticating cells of stem twice the number of leaves in an adjacent leaf whorl (diplostichous), quite regular in pattern. Antheridia at base of oogonia at same node. Oospores black, 600–720 μ long, showing 10–13 striations. Antheridia 300–490 μ in diameter.

Specimens reported by Pieters (1901) as *C. intermedia* from Put-in-Bay do not differ in any apparent aspect from *C. contraria* (cfr. Braun, 1883, p. 153; Robinson, 1906, p. 267).

This species is very similar to *C. fragilis* in appearance, but the latter has triplostichous stem cortication, and the stipulodes at the base of the leaves are rudimentary and obscure. It is very difficult to differentiate *C. contraria* from *C. Macounii* except in good specimens. In the latter species the rootlets generally bear white, starchy bulbils on the rhixoids, the cortical cell pattern is quite irregular with secondary cells overlapping so as to give occasionally a triplostichous appearance, and the plant is dioecious (with rare exceptions with extreme protandry).

Illustrations: Groves and Bullock-Webster, 1924, pl. 23; Migula, 1897, p. 436, and 1925, p. 228.

Localities: Haunk's Pond—*R. D. Wood 13*, Aug. 7, 1940 (F), *14* (RDW); Put-in-Bay—*A. J. Pieters a-71*, July 22, 1898 (NY) as *C. intermedia* A. Br.; protected shoal on Lake Erie shore of gravel just W. of Fisher's pond, Middle Bass, 2 inches of water—*R. D. Wood 104*, Aug. 27, 1940 (F); in bayou along east shore of Put-in-Bay on South Bass, just N. E. of Perry Monument, 6 inches of water—*R. D. Wood 105*, Aug. 27, 1941 (F), is a form with nearly naked leaves; Gibralter dock to west along shore—*R. D. Wood 107*, Aug. 27, 1941 (F), a deep water attenuated form; dock at Gibralter, Put-in-Bay, 3 feet of water—*R. D. Wood 108*, Aug. 27, 1941 (F); Blue Hole of Castalia, Erie County—*J. C. Myers 15, 16, 17*, Aug. 9, 1940 (F), and *N. B. Green 4*, Aug. 18, 1946 (RBG), as *C. vulgaris* L.; Miller's Blue Hole, Sandusky County—*R. B. Gordon 6* and *7*, June 28, 1946 (RBG); Marl Pit, Castalia, Erie County—*R. B. Gordon 1*, Aug. 7, 1946 (RBG).

9. **Chara Macounii** (Allen) Robinson, Bull. N. Y. Bot. Gard. 4: 281, 1906.
Chara aspera var. *Macounii* Allen, Bull. Torrey Bot. Club, 9: 44, pl. 21, fig. B, 4–6, 1882.
Chara aspera Willdenow, Mag. Ges. naturf. Freunde Berlin, 3: 298, 1809. Daily, Butler Univ. Bot. Studies, 7: 126, 1945. as "Nearest var. *Macounii* Allen or *Chara Macounii* Allen as Robinson, 6, considered it."

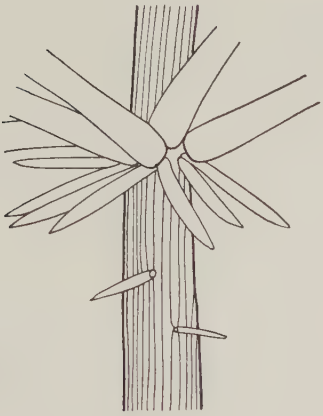
Plate III, Fig. 2

Plant dioecious, or very rarely monoecious with antheridia and oogonia on different nodes; varying up to 10 cm. high. Leaves 6–8 in a whorl, corticated throughout except for 1–3 terminal uncorticated cells. Stipulodes at the base of the leaves reduced to ovate or oblong cells, generally pointed, in two rows. Spine cells present on upper stem internodes, but usually reduced to mere papillae. Corticating cells of the stem diplostichous, though by overlapping of the secondary cells of the cortical nodes may appear triplostichous for a short distance from that node; tending to be very irregular in pattern. Oospores about 420 μ long, showing about 8–10 striations (?).[15] Antheridia about 620 μ in diameter.

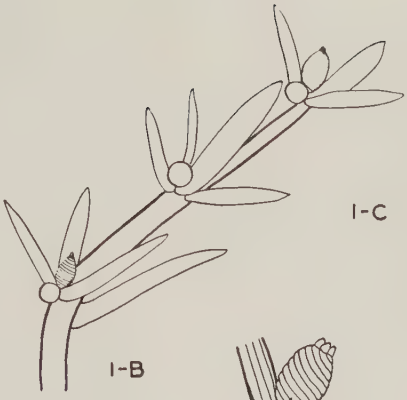
[15]The herbarium material including the type of this species seen by Robinson, Allen, and the author, has all been immature; and exact dimensions of the oospore and number of striae cannot be given with certainty.

EXPLANATION OF PLATE III

FIGS. 1–4. In each case *A*. refers to stem node showing stipulodes at bases of leaves, × 20; *B*. fruiting node of leaf, × 20; *C*. stem cortication, × 20. Fig. 1. *Chara Keukensis* (Allen) Rob. (camera lucida drawings from No. 46, Characeae Americanae Exsiccatae, author's herb.). Fig. 2. *C. Macounii* (Allen) Rob. (2-A and 2-B after Allen; 2-C modified from Allen). Fig. 3. *C. contraria* Braun *ex* Kütz. (3-A camera lucida drawing from *R. D. Wood 14* (RDW); 3-B after Migula; 3-C after Woods). Fig. 4. *C. fragilis* Desv. *ap.* Lois. (4-A and 4-B after Woods; 4-C camera lucida drawing from *R. D. Wood 103* (F)).

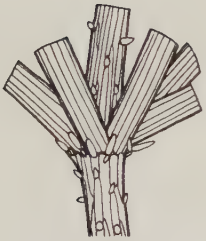


1-A



1-B

1-C

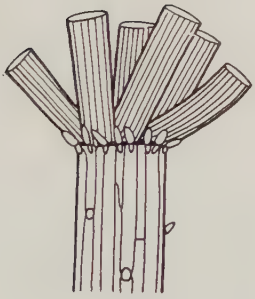


2-A

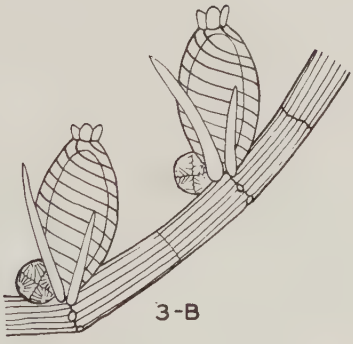
2-B

2-B

2-C

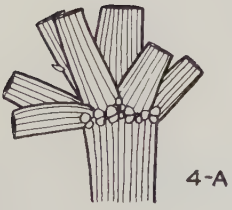


3-A

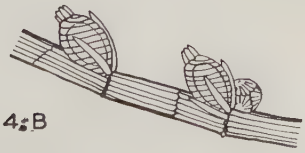


3-B

3-C



4-A



4-B

4-C

This plant was reported by Pieters (1901) as *C. aspera* Willd., but is represented in his collections at the New York Botanical Garden by a nondescript fragment. It appears to be most similar to *C. Macounii* in all ascertainable respects, but is treated here as a doubtful record.

This species is very difficult to differentiate from certain forms of *C. contraria* (cfr. *C. contraria*) except with excellent material. Certain varieties of *C. fragilis* are very similar, but I have no records of these varieties in the region. All three species form compact tufted bunches in shallow water and assume much the same appearance in this habitat. Similarly, in deep water all three species form attenuated plants. A careful study of the cortication, rhizoids, and sex organs will frequently be essential for final determination (cfr. *C. fragilis*).

Illustrations: Allen, 1882a, pl. 21.

Localities: Squaw Harbor—*A. J. Pieters 67*, 1898 (NY) as *C. aspera* Willd.

10. **Chara fragilis**[16] Desvaux *apud* Loiseleur-Deslongchamps, Not. sur les pl. à aj. à la Fl. France, p. 137, 1810.

Allen, Bull. Torrey Bot. Club, 9: 37, pl. XXII, 1882. Halsted, Proc. Boston Nat. Hist. Soc. 20: 188, 1879. Woods, Fl. Nebraska, p. 127, 1894. Robinson, Bull. N. Y. Bot. Gard. 4: 279, 1906. Daily, Butler Univ. Bot. Studies, 6: 164, 1944; *ibid.* 7: 129, 1945.

Plate III, Fig. 4

Plant monoecious, varying up to 75 cm. high. Leaves 6–9 in a whorl; corticated throughout except for the terminal 1–3 cells. Stipulodes at the base of the leaves rudimentary. Spine cells lacking on stem internodes. Corticating cells of the stem three times the number of leaves in an adjacent leaf whorl (triplostichous), very regular. Antheridia occurring at base of oogonia at same leaf node. Bract cells of oogonia generally exceeding oogonia in length. Oospores black, 550–720 μ long, showing 10–14 striations. Antheridia about 500 μ in diameter.

This species is characteristic in its smooth appearance with very regularly triply corticated stems and leaves, with no spines on the stem, and the stipulodes obscure (cfr. *C. contraria* and *C. Macounii*).

Illustrations: Allen, 1882a, pl. 21; Woods, 1894, pl. 35; Groves and Bullock-Webster, 1924, pl. 63; Migula, 1897, p. 724, and 1925, p. 242.

Localities: East Harbor—*A. J. Pieters a-33*, 1898 (NY) as f. *brevifolia;* Put-in-Bay—*A. J. Pieters a-36*, 1898 (NY) as f. *subinermis;* Haunk's Pond, Middle Bass—*R. B. Gordon 5*, Aug. 17, 1946 (RBG); Wehrle Pond, on false bottom—*R. D. Wood 103*, Aug. 27, 1941 (F); protected shoal on Lake Erie shore of gravel just W. of Fisher's pond, Middle Bass, 2 inches of water—*R. D. Wood 104*, Aug. 27, 1941 (F) as *C. contraria*, but includes fragments of *C. fragilis*.

11. **Chara Keukensis** (Allen) Robinson, Bull. N. Y. Bot. Gard. 4: 273, 1906.

Chara gymnopitys var. *Keukensis* Allen, Bull. Torrey Bot. Club, 20: 120, 1893.

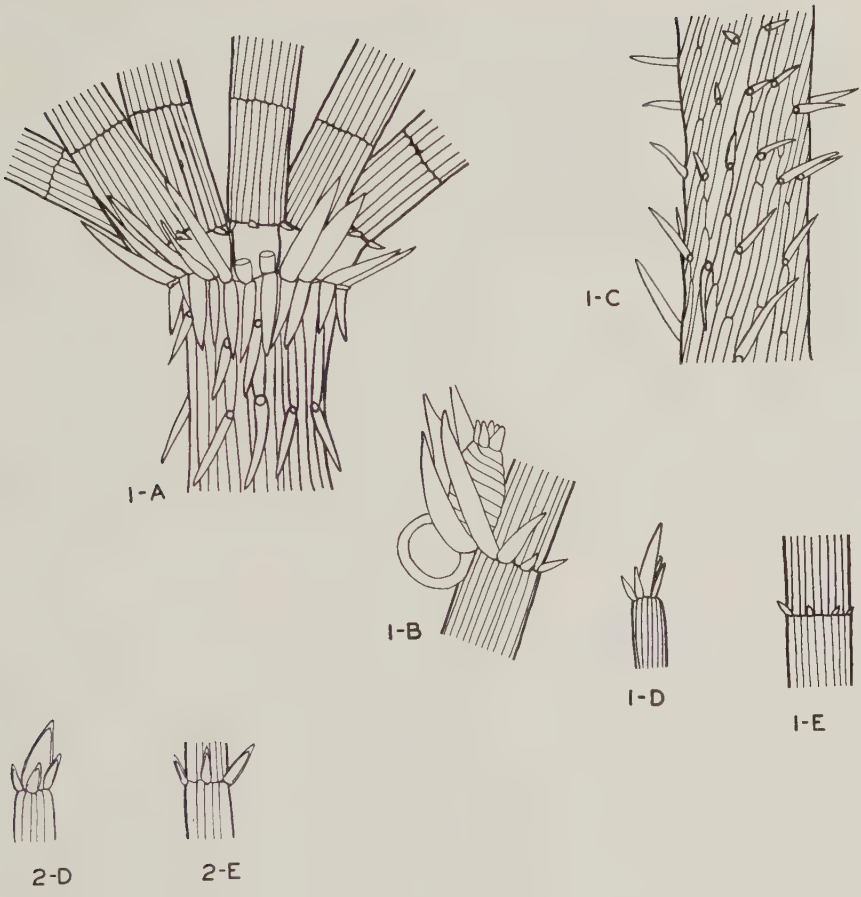
Plate III, Fig. 1

Plant monoecious, 3.5–8 cm. high. Leaves totally uncorticated, mostly 8 in a whorl. Stipulodes at base of leaves in one row, well developed and spreading. Spine cells on stem internodes few. Corticating cells of stem fundamentally twice the number of leaves in an adjacent leaf whorl (diplostichous), because the secondary cortical cells develop well in one direction. These cortical cells may develop for only a short distance in the other direction, giving an incompletely triplostichous condition. Leaflets at sterile leaf nodes developed into large cells equal in

[16]According to G. O. Allen (1940) and Zaneveld (1940) *Chara globularis* Thuillier, Fl. des Env. Paris, ed. 2, p. 472, 1799, is an earlier synonym of this plant.

EXPLANATION OF PLATE IV

FIGS. 1–2. In each case *A.* refers to stem node, × 20 (in fig. 1-A two stipulodes removed to show uncorticated basal leaf internode); *B.* fruiting node of leaf, × 20; *C.* stem cortication, × 20; *D.* terminal cells of leaf, × 20; *E.* leaflets at sterile leaf node, × 20. Fig. 1. *Chara Haitensis* Turp. (camera lucida drawings from *W. MacLain 21* (RDW)). Fig. 2. *C. compacta* Rob. (camera lucida drawings from *R. D. Wood 41* (RDW)).


1-A
1-B
1-C
1-D
1-E
2-D
2-E
2-A
2-B
2-C

size to the leaf internodes. Bracts at base of oogonia much longer than oogonia. Antheridia and oogonia generally together at the same leaf node. Oospores 440–490 μ long, showing 9 somewhat faint striations. Antheridia 250–280 μ in diameter.

This species is distinct from all other local Characeae by regularly having uncorticated leaves but completely corticated stems. Certain forms of *C. contraria* with only one or two corticated leaf nodes might possibly be confused with it unless careful inspection is made of the whole leaves and cortications.

The plant was reported by Pieters (1901) as *C. Hydropitys* forma *compacta*. The specimen at the New York Botanical Garden is quite good, and adequate to make the present determination, which concurs with Robinson's written annotation.

Illustrations: None.

Exsiccatae: Allen, Char. Amer. Exsicc. No. 46, 1893; Robinson, *in* Collins, Holden & Setchell, Phyc. Boreali-Amer., Fasc. XXX, No. 1491, 1911.

Localities: Squaw Harbor—*A. J. Pieters 65*, 1898 (NY) as *C. Hydropitys* f. *compacta*, redet. *C. Keukensis* by Robinson.

12. **Chara Haitensis**[17] Turpin, *in* Dict. Sci. Nat. Veg. Acot., vol. 8, pl. at p. 164, 1817.
Robinson, Bull. N. Y. Bot. Gard. 4: 291, 1906.
Chara gymnopus Michauxii Braun, Amer. Jour. Sci. 46: 93, 1844 (*nomen*); Monatsb. K. Akad. Wiss. Berlin, 1858, p. 362, 1858.
Chara gymnopus var. *Michauxii* Braun *in* Allen, Char. of Amer. I, p. 2, 1880.

Plate IV, Fig. 1

Plant monoecious, varying up to 40 cm. high. Leaves 12–16 in a whorl, 3–4 cm. long, corticated except for the apical cell and the basal leaf internodal cell. Stipulodes at the base of leaves well developed, in two rows, the upper longer than the lower. Spine cells few except on the upper internodes. Corticating cells of the stem three times the number of leaves in an adjacent leaf whorl (triplostichous). Spine cells at sterile leaf nodes reduced. Bract cells at the base of oogonia shorter than the mature oogonia. Antheridia occurring at base of oogonia. Oospores 600–900 μ long, showing 13–16 striations. Antheridia about 560 μ in diameter.

From other Charas with corticated leaves, except *C. compacta*, this species is distinct by having the basal leaf internodes invariably uncorticated, and by having two rows of stipulodes at the base of the leaves well over 4 times as long as wide. From *C. compacta* it differs in having the antheridia and oogonia occurring together at the same leaf node, and in its generally much longer leaves which are quite straight instead of curved, giving a brush-like appearance to a leaf whorl. Further, the leaflets at the sterile leaf nodes are nearly obscure in *C. Haitensis;* whereas they form a ring of spines in *C. compacta.*

Illustrations: Turpin, *loc. cit.*

Exsiccatae: Allen, Char. Amer. Exsicc. No. 9, 1880; Robinson *in* Collins, Holden & Setchell, Phyc. Boreali-Amer., Fasc. E, CIV, 1911.

Localities: East Harbor—*A. J. Pieters a-31*, 1898 (NY) as *C. sejuncta;* East Harbor—*W. MacLain 21*, July 10, 1940 (RDW); Portage River—*A. J. Pieters a-53*, 1898 (NY) as *C. gymnopus* var. *Michauxii.*

13. **Chara compacta**[18] Robinson, Bull. N. Y. Bot. Gard. 4: 297, 1906.

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[17]This name appears on an adequate illustration of the plant. No written description of the plant occurs in the text. According to the International Rules, a plate is adequate to establish priority for dates prior to 1908. In this interpretation, Robinson was justified in re-establishing this synonym.

Zaneveld (1940, p. 203) included this species in his new form *C. Zeylanica* forma *typica* Zanev., and transferred it to the earlier homonym *C. Zeylanica* Willd., Mém. Ac. Roy. Berlin, 1803, p. 86, 1805.

[18]This species is given with some reservation. The specimens vary greatly in character of sterile leaf node leaflets; but the size of stipulodes, manner of their not concealing the gymnopodous leaf internodes, number of striations of oospore, and pattern of cortications most closely approach Robinson's type material of this species. Whether this species can be maintained at all is questionable, as the bases of distinction are so relatively minor. Groves (1911, p. 40) includes it under *C. sejuncta* Braun, which the writer feels is probably a more correct disposition.

Chara sejuncta Braun, according to Allen, Bull. Torrey Bot. Club, 21: 526, 1894.

Chara sejuncta forma *compacta, subinermis, microptila, unilateralis, macrospora, munda* (*nomen*), Allen, Char. Amer. Exsicc. unnumbered specimen (Lake Champlain and Lake Saratoga), 1894.

Plate IV, Fig. 2

Plant monoecious, but antheridia and oogonia occurring at different nodes, frequently on the same leaf; up to 20 cm. high. Leaves 12–14 in a whorl, 1.5–2.2 cm. long; corticated throughout except for the apical cell, and the basal leaf node. Stipulodes at the base of the leaves well developed, the upper row 920–1500 μ long, usually not quite reaching the top of the swollen leaf internodes. Spine cells rather frequent on upper stem internodes. Corticating cells of the stem three times the number of leaves in an adjacent leaf whorl (triplostichous). Leaflets at sterile leaf nodes forming a ring of spines. Bract cells at base of oogonia shorter than the oogonia. Antheridia and oogonia occurring at different nodes, but frequently on the same leaf. Oospores 730–770 μ long, showing 10–12 very conspicuous striations. Antheridia 360–400 μ in diameter.

This species is rather difficult to recognize in the field as distinct from *C. contraria*, *C. fragilis*, and especially *C. Haitensis* (cfr. *C. Haïtensis*). However, the effect of the naked basal leaf internodes with the stipulodes gives the living material the appearance of having a very short basal leaf internode, a feature of both *C. Haitensis* and *C. compacta*. But for positive determination of the latter two species, the plants must be inspected microscopically for the leaflet structure, cortical pattern of the stem, number of striations of oospore, and especially the placement of the sex organs.

Illustrations: None.

Exsiccatae: Allen, Char. Amer. Exsicc. *loc. cit.*

Localities: Squaw Harbor—*A. J. Pieters a-37*, Aug. 26, 1898 (NY) as *C. Michauxii;* Haunk's Pond, Middle Bass—*R. D. Wood 41, 43, 45*, Aug. 9, 1940 (F) as *C. sejuncta* f. *compacta; 42, 44* (RDW); *ibid. 21, 22* (RDW) as *C. sejuncta.*

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DDT and the Insect Problem

This is one of the most welcome books to come to the attention of the writer, because it brings together complete up-to-date information about the use of this new and important chemical insect-killer. It is an excellent summary of a great number of scientific facts that have been written concerning the methods and techniques employed in tests for control of the many insects affecting man. Written in a non-technical easy-to-read style, it holds the reader's interest from the opening to the concluding chapter.

The contents by chapters are: Introduction; Insects and Insecticides; Chemistry and Pharmacology of DDT; How to Use DDT; DDT at War; Man's Health and Comfort; Agriculture, Forest, Shade and Fruit Tree Insects.

The sources of the information are given in the list of references at the end of each chapter. Although all the published literature on the subject is not listed, it appears that all the essential reports were reviewed.

This book will be a handy reference for all professional entomologists, as well as the pest control operators and general users of DDT.—*R. H. Davidson.*

DDT and the Insect Problem, by James C. Leary, William I. Fishbein and Lawrence C. Salter. McGraw-Hill Book Company, New York City. 176 pp. 1946. Price $2.50.

OIL IN GERMANY

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The subject "Oil in Germany" was and is of great importance to us because it was and still is a very essential part of Germany's war potential as well as of her peacetime economy.

World War I revealed the importance of oil to military operations. Lord Curzon made the long-remembered statement that the Allies floated to victory on a sea of oil. Marshal Foch added that in war a drop of gasoline is worth a drop of blood.

World War II clearly demonstrated the absolute necessity of oil in war. Not only did the want of it, the need of it, breed the force which attempted to obtain it, but it also played a leading part in the strategy of the victorious side. It is smarter to ground planes and put out of commission tanks by destroying their oil depots than to risk more men and machines by fighting them. Therefore all information concerning the natural and synthetic oil of Germany was classified information and hard to get. Some of the data presented in this study could not be checked or rechecked because of lack of information from the Russian sector of Germany.

First, the geographic location of Germany's natural and synthetic oil, petroleum refineries, oil centers, firms, etc., will be described. Then an oil estimate will be made and finally the elimination of Germany's production of synthetic gasoline and oil will be discussed. It is beyond the scope and time of this study to describe the various processes (Hydronation, Hydrogenation, Carbonization, Bergius, Fischer-Tropsch, Winkler, and other I. G. Farben-processes) used in the production of synthetic oil.

It should be remembered that Germany lacked sufficient natural oil within her own boundaries to maintain her military machine and that even after gaining all the oil in Central Europe, she still lacked enough oil to wage a successful war. This lack was a direct stimulus to the experimentation in snythetics and the production of synthetic oil. Germany built a large number of synthetic plants, all of which were subject to raids during the war. The most important one of these synthetic plants was the Leuna Works at Merseburg. This plant was wrecked by allied bombing, but recently has been restored to 40% of its capacity. It is supplying gasoline to the Russian occupational forces now. Forty percent of the Leuna plant was completely destroyed and about 70% of it was unroofed. Leuna Works is a limited liability corporation whose stock was owned by the I. G. Farbenindustrie A.G. combine. Since Allied confiscation of the German assets of the I. G. Farben-combine, the title to the Leuna Works as well as to many other synthetic oil plants rests with the Allied control council for Germany. At present the plant is employing about 18,000 workers, about half of its wartime peak.

The situation in the other plants listed is similar.

I. Natural Oil.—Production of natural oil is centered in North West Germany at:

Nienhagen—Production about 300,000 tons per year.
Rietberg—Production about 300,000 tons per year.
Heide—Production about 50,000 tons per year.

Total production of natural crude oil in Germany for 1942 is estimated at 800,000 tons.

II. Petroleum Refineries.—Total refining capacity in 1938 was 3,000,000 tons a year. It was centered in the Hamburg area and in the Hanover area.

A secondary concentration was on the Rhine and Ruhr, chiefly at

Emmerich.
Dortmund.
Düsseldorf.

Imports were also refined at Regensburg.

III. Synthetic Oil.—Germany's main source of oil supply. Principal synthetic oil plants:

Location	*Name of Plant*	*Estimated Annual capacity (1,000 Tons p. a.)*
Bergius—Hydrogenation Plants—		
Leuna—Merseburg	Ammoniawerke Merseburg GmbH	400
Pölitz—Stettin	Hydrierwerke AG	400
Scholven—Buer (Rhur)	Hydrierwerke Scholven Hibernia AG	350
Gelsenkirchen (Rhur)	Gelsenkirchen—Benzin AG	325
Troglitz—Zeitz	Braunkohle—Benzin AG	320
Magdeburg	Braunkohle—Benzin AG	300
Wesseling	Union Rheinische Braunkohlen Kraftstoff AG	250
Böhlen—Rotha	Braunkohle—Benzin AG	200
Lützendorf Mucheln	Wintershall AG	125
Welheim Bottrop (Rhur)	Rhurõl GmbH	100
Blechhammer (Silesia)		
(a) North	IG Farbenindustrie	750
(b) South	IG Farbenindustrie	750
		4,275

Location	*Name of Plant*	*Estimated Annual Capacity (1,000 Tons p. a.)*
Fischer-Tropsch Plants:		
Ruhland—Schwarzheide	Braunkohle—Benzin AG	400
Lützendorf—Mücheln	Wintershall AG	200
Rauxel (Rhur)	Klockner—Wintershall AG	200
Homberg (Ruhr)	Treibstoffabrik Rheinpreussen	200
Holten (Ruhr)	Rhurbenzin AG	130
Wanne—Eickel (Rhur)	Krupp Treibstoffwerke	130
Dortmund (Ruhr)	Hoesch—Benzin GmbH	130
Deschowitz	Schaffgotsch'sche Benzin GmbH	110
Kamen-Dortmund (Ruhr)	Chemische Werke, Essener Steinkohle AG.	50
		1,550

IV. Oil Centers.—The following list indicates the storage capacity available at the principal oil storage centers. In each of the town areas it is distributed over a number of individual plants, but in no case is it possible

to give even an estimate of the actual quantities which are likely to be in storage.

Place	*Capacity in Tons*
Berlin	68,900
Bremen	748,800
Bremerhaven	459,700
Danzig	5,800
Duisburg	66,500
Düsseldorf	31,800
Emden	43,500
Frankfurt-Main	141,200
Hamburg	1,361,200
Hanover	287,300
Kiel	737,300
Köln	14,000
München	69,000
Rostock	11,000
Stettin	187,000
Stuttgart	17,500
Wilhelmshaven	221,000
	4,471,500

The following underground army oil storage depots are definitely known:

Place	*Capacity in Tons*
Hitzacker (Lüneburger Heide)	2,400,000
This depot consists of 114 "holes" or "departments," each of which contains five storage tanks.	
Farge (14 miles NW of Bremen)	340,000
Nienburg (Lüneburger Heide)	193,200
Loccum (Lüneburger Heide)	15,600
	2,948,800

These figures are by no means complete, but they represent the locations of the principal depots. We may assume that the others were destroyed during the war.

V. Major Oil Firms.

Firm	*Location*
Bremer Chemische Fabrik A. G.	Klaffenbach (Erzgebirge)
I. O. G. Mineralöl-Raffinerie Herzog	München-Ottobrunn
Karl Pohlmann Mineralöl-Raffinerie	Kerbach (Kassel)
Teutonia Mineralöl-Raffinerie	Berlin-Rudow
Alfred Teves	Frankfurt (Main)
Hans R. Schroeter	Magdeburg
Deutsche Hydraulik und Präzisions-werke G.m.b.H.	Berlin-Wittenau
Deutsche Gasolin A. G.	Emmerich
Deutsche Vacuum Öl A. G.	Oslebshausen
Mitag Deutsche Treibstoffe A. G.	Regensburg
Nerag A. G.	Misburg
Rhenania-Ossag Mineralwerke A. G.	Königsberg (Pr.)
Shell-Floridsdorfer Mineralölfabrik A. G.	Wein-Floridsdorf

The present capacity of these firms is unknown.

VI. Oil Estimate.

It has been estimated that the Germans produce about 267,000 barrels daily now, while our daily production in 1946 was 5,070,000 barrels, plus imports of 370,000 barrels, totally 5,440,000 barrels. There is a tremendous demand for oil in Germany now and Germany has to rely heavily upon petroleum imports from the Middle East and other areas. Germany is forced to convert cars, trucks, etc., to charcoal and similar substitutes. The German nation is very poor in regard to its oil supply. In addition to it the most important oil fields and refineries are dominated by affiliates of the large oil groups, in particular Standard-Vacuum and Shell-group.

VII. Germany's Oil and the Future.

Briefly we have surveyed the oil situation as it stands in Germany today. We have seen that production is low principally due to the effects created by World War II. Our bombers destroyed or damaged oil installations from the refineries of Bordeaux to the oil fields of Ploesti. It will be many years before all of these installations are operating on a former capacity basis. On the other hand World War II developed and proved the value of synthetic oil.

In accordance with the Berlin Protocol of March 28, 1946, the Allied Control Council is to determine the amount and character of the industrial capital equipment unnecessary for the German peace economy and therefore available for reparations. All industrial capital equipment for the production of synthetic oil and gasoline is to be eliminated. But 14 lines later the same document states "Facilities for the production of synthetic gasoline and oil, synthetic ammonia and synthetic rubber, and of all ball and taper roller bearings, will be temporarily retained to meet domestic requirements until the necessary imports are available and can be paid for." There is a contradiction between both policies. On one hand we would like to eliminate Germany's war potential and on the other hand we are retaining there the most important war facilities.

We all know that oil is the raw material for a thousand purposes, the source of power in industry, the source of fuel and lubricants and that it must not be kept from or taken away from those who need it. The Atlantic Charter stated that all nations should have the right to trade and access to raw materials of the world whenever necessary to their prosperity. This applies to Germany too.

We also know that Germany will not be able to pay for oil imports for quite some time. Are Standard and Shell willing to accept Christmas toys for oil again as they had to accept them before World War II?

Should we let the Russians have the German facilities for the production of synthetic gasoline and oil? Soon after Anschluss German interests "legally acquired" title to all foreign and domestic oil properties in Austria. This acquisition is at present a cause of considerable concern to the four powers. Under the Potsdam Agreement the Russians were given the right to take German holdings in Austria as reparations. It is the opinion of the writer that such holdings can not properly be considered German, if acquired during the war. A restoration of all property rights to the prewar owners should be attempted. There must not be any transfer of facilities as long as domestic oil requirements are not met.

But at all times there should be a rigid control of all facilities for the production of synthetic gasoline and oil even though converted to civilian production, in order to ensure that these plants are not again used for war purposes. Elimination or transfer of the facilities mentioned do not seem advisable as such acts would cause considerable unemployment in Germany. Reconversion and control seem to be better solutions.

Amiable policy between nations on the subject of German oil cannot bring everlasting peace within itself, but it can be of great assistance, while lack of such an amiable policy can be a great hindrance to peace. All nations seek wealth. Oil is wealth. A proportionate sharing of it is essential to a lasting peace..

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Fleas of Western North America

The study of western fleas has been attractive to the student of descriptive zoology because of the variety and newness of the fauna. Many of the species that have been found were new. Also the presence of plague has made the study of fleas in this area necessary. The classification of fleas is an intriguing subject and this may be illustrated by the fact that the 238 species and subspecies are distributed in 66 genera. Interest has lagged in recent years in the hollow curve of distribution but my guess is that a curve resulting from use of data on fleas would be rather startling.

This book is in three parts dealing with students of fleas, medical significance, field and laboratory technique, and morphology in relation to taxonomy (37 pages); systematic classification and a geographical index of the western fleas and of the eastern fleas compiled from Fox (347 pages); and host indexes (121 pages). This is a bibliography of recent papers, an index to species arranged alphabetically and also according to describer, and a comprehensive general index. An abundance of illustrations, and good materials and printing make this a very attractive book. Its value as an addition to entomological literature is obvious and it will be useful to health officials and sanitary officers, as well as to entomologists.—*C. E. Venard.*

Fleas of Western North America, by C. Andresen Hubbard. 532 pages, illustrated, 6x9, cloth bound. 1947. Iowa State College Press, Ames, Iowa. Price $6.00.

Animal Breeding Plans

The third edition of this well-known book on the principles and practices of animal breeding continues the record of excellence established by the two previous editions. The organization and content are essentially unchanged even though new phrasing and new references occur in many places, adding more than one hundred pages of text. The chapter on Sire Indexes is completely recast.

This book, which has served students of animal breeding for a decade, actually may be used by a much wider public, including students of all phases of genetics. This is due to the fact that the author has clearly and simply described the basic concepts and methods of statistical genetics. A better exposition of the effects of selection and various schemes of inbreeding on the gene frequencies of a population does not exist elsewhere in the literature.—*E. L. Green.*

Animal Breeding Plans, by Jay L. Lush. Third ed. viii 443 pp. 50 figs. Ames, The Collegiate Press. 1945. $3.50.

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